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FIVE YEARS OF CACAO RESEARCH. 1930-1935.

ALTHOUGH prior to 1930 there had been many researches carried out on cacao in different parts of the world, it is perhaps safe to say that this crop had not received the same amount of detailed attention as other tropical agricultural products of major economic importance. At the time when the Cacao Research Scheme was launched at the Imperial College of Tropical Agriculture it represented in important respects a new departure. It was the first organized attack, by a staff specially appointed for the purpose, on the botanical and soil problems encountered in the cultivation of this important crop. It was also the first investigational work on this crop to be financed jointly by producers and manufacturers in the interests of the industry as a whole. The co-operation of the cacao-producing countries of the British Empire and some of the leading manufacturers of cocoa and chocolate enabled broad aims to be adopted. The history of the genesis of the scheme was recorded in a preface to the First Annual Report where it was shown how logically it developed from the conception of long range research that has been laid down as the appropriate function of institutions such as this College.

As originally conceived, the Scheme was intended to run initially for five years and funds were provided for that purpose. It was believed that during this period certain preliminary researches would be completed, and it was anticipated that their results would inevitably demonstrate the necessity for continuation and extension. The four annual reports that have now been published have established the fact that these preliminaries have been accomplished, and also that much further work requires to be undertaken. In this connection it must always be remembered that we are dealing with a perennial crop in which the final results as measured by crop yields are naturally much slower to obtain than in the case of annual crops.

The first five-year period is now drawing to a close, and as the whole organization is coming up for review a concise statement of the position should interest not only the present subscribers to the Scheme but also all who hold a stake in the cacao industry. The annual reports are necessarily long and complicated by scientific detail, and the officers responsible for the planning and direction of the technical work have accordingly been requested to prepare the two

summaries which appear in this issue and follow this article. Professor E. E. Cheesman describes the botanical work carried out by Messrs. F. J. Pound and E. E. Pyke, and Professor F. Hardy the chemical and ecological investigations of Mr. J. A. McDonald.

The criticism has been sometimes advanced that the results obtained are more particularly applicable to Trinidad and West Indian conditions, but a perusal of the summaries will show that such criticism is not well founded. The Central Cacao Scheme had to have its headquarters somewhere and in many ways Trinidad is the most suitable centre for this work. This island can show a range of cacao types probably the widest in the world, and thus affords an unrivalled field for selection work and for studies of compatibility, physiology and similar problems. It also possesses a considerable variety of soil types and varying climatic conditions, and so affords good conditions for pursuing the study of the ecological requirements of the plant. In reading these summaries therefore, it should always be borne in mind that while of necessity the Trinidad crop and Trinidad conditions have been utilized, they have been used for the purpose of establishing general principles which are applicable to other countries and other classes of cacao. This procedure is strictly in accordance with the conception of long range research and leaves to the various Colonial Agricultural Departments or research workers in other parts, the necessary modification of details to suit their particular circumstances. It was never supposed that all the problems of a crop which is grown in four continents could be studied in one place, but there is still a vast amount of fundamental knowledge to be acquired about cacao that can be applied universally when available. It is the policy of those in charge of the Cacao Research Scheme to select its problems from among those which have the widest bearing.

In times such as these, when there is apparent over-production and prices are so phenomenally low, it may seem strange to some of our readers that increased yields should be the main object of our research. There is nothing really illogical in this. It is really a matter of the essential difference between *production* and *productiveness*. The latter is mainly a question of increasing the yield per acre and is an index of efficiency, and enhanced efficiency is the final aim of all agricultural research. Cacao, with one or two minor exceptions perhaps, is grown at present by extensive methods. It is treated more as a forest than an orchard crop. Large areas have been relied on in the past to give the necessary production with a lack of attention to details of cultivation that compares unfavourably with the methods employed on most other orchard and plantation crops. Plantations that have been kept up under these conditions are not in a position to stand up against a long period of depressed prices. They rapidly go down in yield and there are already signs that they are likely to succumb more readily to the inroads of diseases and pests. It seems probable that intensive methods based on a high yield per unit area such as are recommended by the Research Scheme would stand a much better chance of withstanding the economic blizzards of the future.

Concerning the progress made towards specific aims, the summaries speak for themselves, and it only remains for me to stress the fact that a continuation of these researches depends on the judgment they receive from the industry. Considering the depression through which that industry has been and is still passing, its support has hitherto been most encouraging. Nevertheless, the sums contributed for the first five years fell below the original estimates, although those estimates were very modest in proportion to the interests involved. During the latter part of the period funds have been barely sufficient to carry on the work, and tribute must be paid to the loyalty and enthusiasm of the technical officers employed by the Scheme for the way they have carried out their duties under considerable financial difficulties.

At the present stage, if the results achieved are deemed to have justified the relatively small sum expended in obtaining them, it will be desirable for the basis of the research to be broadened. There are important lines of research which it has been quite impossible to open at all. Although it may prove impossible to provide additional funds until times improve, it should be pointed out that failure to consolidate, at the very least, the advances already made, would be disastrous.

Special thanks are due to the Director and officers of the Trinidad and Tobago Agricultural Department for their co-operation. The facilities afforded by an established experimental station such as River Estate have been of incalculable value. In the same way, the cacao planters of this Colony have followed the research with the greatest enthusiasm, and their help and good will have been of the greatest encouragement to us. It is significant that already many of them are beginning to adopt certain measures that have emerged as the result of this research work.

We should like to record our appreciation of the close co-operation that has taken place between the Cacao Research workers and the other officers at the College. It is not generally understood that cacao receives a great deal of attention from several of the College departments which are not connected financially with this research. The problems of cacao economics have been receiving detailed attention for years past, and the Professor of Economics has kept in close touch with the work. Similarly close touch has been kept with the Departments of Mycology and Entomology, who have carried out investigations on certain cacao diseases and pests, while quite recently the Officer in charge of the Low Temperature Station has collaborated in carrying out storage tests on cacao pods, which should have an important bearing in the future in connection with the possibility of interchange of varieties and the introduction of improved types. To all these officers our special thanks are due.

G. E.

THE BOTANICAL RESEARCHES ON CACAO.

By E. E. Cheesman, M.Sc.

Aims.

The general aim of these researches was broadly defined at the outset as "the collection of information necessary for improvement of both yield and quality in the cacao crops of the Empire, with the economic object of increasing the profits of both the grower and the manufacturer." The more specific aims depend on the basic principles of crop improvement. The grower, however skilled and careful, cannot get the best results from inferior trees, and there are undoubtedly many trees on existing plantations that do not pay for their keep. This consideration leads us to *selection*, or an attempt to find some of the best trees in the population, and to *propagation* or attempts to multiply them, when found, to replace the mediocre and the bad. It is worth noting that the breeding of new varieties has no place in the immediate programme, the reason being that the sorting out of existing types is more urgent. Cross breeding operations have gone on in Nature for hundreds of years already, and it behoves the plant breeder to take advantage of the fact before attempting, with little to guide him, to go further.

Important as the constitution of the tree is, however, even the best of trees will not develop its powers without appropriate treatment, and this second consideration leads us to general studies of the way in which the cacao tree lives and grows and builds up its crop. The soil and the environment generally have much to do with the final yield, and these studies are therefore in large part the work of the Chemical Section, but they have also aspects strictly botanical as well as many calling for close contact between the two branches. We have called the more botanical aspects *studies of fruitfulness* because the setting and subsequent development or failure of the fruits were selected for first attention.

Selection.

The successive steps in the process of genetic selection have been as follows :—

1. *Analysis of Requirements.*

The "best" trees are not necessarily those bearing the highest quality of produce, or even those giving the highest yield. They are those most *profitable* when yield, quality and costs of cultivation are all taken into account. The conditions of the cacao industry indicated that increased productiveness should be placed first, and quality (so far as it depends on the tree) second. The two cannot in practice be separated, but we did in fact attack first the problem of finding the highest yielders, and as it happened the quality problem partly solved itself. Yield per tree depends on the number of pods borne and the amount of cacao in each pod. Yield per acre, which is more important, depends also on the size of the tree, governing the number of effective trees per acre. Knowing that cacao trees vary widely in the number of pods they bear, we had first to find out whether the heaviest bearers were also the highest yielders.

2. *Determination of Sampling Constants.*

As large numbers of quantitative measurements had to be made, and had to be of known precision, the first step was to determine the size of sample necessary to give a dependable result. Investigations of sampling methods occupied one crop season, but saved time in the long run. Thirty pods were found to constitute an adequate sample for characterising the fruit of any one tree, giving means for some measurements within five per cent. and for others within ten per cent. of the truth (1931 Report).

3. *Quantitative Survey of Trinidad Cacao.*

Standard pod samples were examined from nearly a thousand trees (actually 950) distributed in twelve blocks in different parts of Trinidad. These trees served as a fair sample of the population on good estates, and indicated the range of variation within which selection had to work. The range found is concisely expressed in the following table from the 1932 Report, the modes for all Trinidad being probably a little on the poorer side in each case.

Dimension.	Lower Limit.	Upper Limit.	Mode.
Length ..	10.5 cms.	23.5 cms.	16.0 cms.
Diameter ..	6.1 cms.	10.6 cms.	8.0 cms.
Ratio (Shape) ..	1.3	2.7	1.95
Shell thickness	0.8 cms.	2.4 cms.	1.4 cms.
No. beans ..	15	45	34.5
Pods to the pound ..	6	22	10.5
Weight of a single bean ..	1.1 gms.	5.6 gms.	3.2 gms.

4. *Qualitative Survey.*

During the quantitative survey, extensive notes were also made on such characters as colour, shape and surface texture of pods, in the hope that some correlation might be found between such easily observable features and the value of the trees showing them. Success would have meant the saving of much time-consuming measurement, but it was found that good trees may occur in almost any of the 110 "type" classes recognized. Consequently qualitative observation could not replace quantitative measurement although it provided useful indications in many cases. (1932 Report.)

5. *Fixing of First Standard.*

The quantitative survey showed that the most important variation affecting yield, apart for number of pods borne, is the value of the individual pod. The table above shows that some trees bear pods of which six make 1 lb. of dry marketable cacao (1) whilst most frequently 10 or 11 and from some trees 22 pods are needed

(1) The quantity "pods to the pound" is calculated from the mean weight of *wet* cacao per pod for the tree in question, assuming 60 per cent. loss in weight in fermentation and drying. The factor is sufficiently accurate at this stage, considering the great variation in wet cacao weight from tree to tree.

to give the same weight. Rather wider extremes have been found since. This result proves that number of pods borne means very little until corrected by " pod value ".

The value of a pod cannot always be judged from its external size, because of the great differences in shell thickness. It must be judged on wet cacao weight, and first selections were based on this quantity alone, a specially devised spring balance being employed for its rapid determination.

The selection limit was placed at $7\frac{1}{2}$ pods to the pound. About two per cent. of the Trinidad tree population have pods of which $7\frac{1}{2}$ or less make a pound of dry cacao, and this two per cent. includes a certain proportion of heavy bearers. The other 98 per cent. also includes some heavy bearers, which have not been altogether neglected, but, for reasons that will appear, work from this point was mainly concentrated on finding and tagging 1,000 trees passing this standard of pod value. (1932 Report.)

6. *Considerations of Quality.*

Quality in cacao depends on many factors, of which some cannot be studied in the preliminary phases of research. Size of bean, however, is one that can be dealt with. The table reproduced above shows that the mean wet weight of single beans from different trees varies from 1.1 to 5.6 grammes, being most usually about 3.2 grammes in the sample examined. There is therefore scope in the population for improvement, if it can be obtained without sacrifice of yield. From the quantitative survey a most important fact came to light, namely that the pods containing a heavy weight of cacao contain also larger beans than the average. Thus by the method adopted in the selection of high yielders, quality, so far as it depends on size of bean, is automatically improved, and the trees producing the smallest beans are excluded. This observation confirmed the method of first selection on pod value as appropriate. (1932 Report.)

7. *Second Selection on Bearing.*

In the second stage, the 1,000 trees selected on pod value are being reduced to 100 on final yield. As most of the first tagging was completed in 1933, there will be at the end of the current (1934-35) crop three years' actual yields recorded for most of the 1,000, and the reselection will be completed on those figures. The figure of 100 has been fixed in deference to the fact that the only final proof of a tree's value is the behaviour of its progeny. This test has still to come, and sufficient selections must be kept in hand to allow ruthless elimination of any that fail under it. There must then be enough still left to include types of differing agricultural characteristics, for a good tree in one district may be a poor one for another, and no single " best " type can possibly be found for all the conditions under which cacao is grown even in Trinidad, much less in the Empire.

The procedure during re-selection has taken account of yield per acre rather than yield per tree. This of course cannot be done precisely, but trees on Trinidad estates vary very much in age and size, and heavy bearers are often found to be large specimens occupying two, three or four times their fair share of the land. Such trees have been handicapped on the selector's estimate of the area effectively occupied, and unless their gross yields are really extraordinary they commonly fail to pass the standard. The standard is an estimated yield of one ton of dry cacao per acre, calculated from number of pods reaped, pods to the pound, and ground occupied. For a normal tree at 12 × 12 ft. spacing this represents 7 lb. or 50 pods (approximately) and it is a little startling at first to find 50-pod and 100-pod trees ranking as more efficient than most 200-pod trees. Where the latter require 10 to 12 pods to the pound and occupy some 24 × 24 ft. however, as they often do, there is no escaping the fact of their lower true yield. Their actual efficiency is further reduced by the lower quality of their produce in nearly all cases, and by the greater cost of harvesting and breaking twice as many pods to obtain an equivalent weight of cacao.

There has been no difficulty whatever in finding sufficient good bearers among the 1,000 trees originally tagged to make up the 100 second selections. This may be partly due to the fact that no tree was tagged at all unless it had a fair crop of pods at the time its pod value was measured. Selection rules are not hard and fast in both directions, and at each stage thought has been devoted to accelerating the next. It should perhaps be mentioned that the 100 trees given I.C.S. (Imperial College Selection) numbers occur scattered over many plantations, on all kinds of soils and under various conditions. In all cases they far outstrip their immediate neighbours in yield, so that there is no reason to suspect a specially good soil " pocket " as the cause of their high performance. Further, those which have been tagged long enough for the observation of several successive crops have yielded in many cases more than the quantity of cacao originally estimated and none of them has fallen seriously short in any year. The calculated yield of many is well above the one-ton standard, but 30 cwt. seems to be about the upper limit of potential yield under present conditions. As this is at least ten times the present average, it allows ample margin for progeny to drop below the performance of their parents and still give substantial increases. The most interesting feature of the information obtained to date is perhaps the virtual absence of antagonism between yield and quality as expressed by bean size. The selection standard of $7\frac{1}{2}$ pods to the pound has been lowered in a few cases to admit a certain number of high yielders of second class beans, which may be useful types for some localities, yet the yield of these in no case exceeds that of the best of the first class trees. (1933 and 1934 Reports.)

8. *Comparisons of Progenies.*

The crucial test of our selections remains to be made, and depends on the continuation of the Cacao Research Scheme, but it may be well to indicate here what we have provisionally planned

as the next step. The 100 selected trees are to be propagated vegetatively by several methods and set out in a series of field trials. A comparison will thus be obtained not only of the vegetative progenies themselves but of the propagation methods as well. There will be 100 individuals of each selection, so that when they come into bearing adequate samples may be prepared for commercial opinions. Yield, agricultural behaviour and commercial value will all be more readily assessed in this manner than could ever be the case from single trees, and the final result should be a series of standard varieties, of known characteristics, from which the grower can choose those best suited to his own estate or to particular fields on it. It may be added that seedling progenies are already being planted out on several estates, from which we hope to get information concerning the value of our selections as seed parents although we visualise the greatest improvements as likely to result from vegetative propagation, discussed in the next section.

Propagation.

The reasons for instituting research on methods of propagation may be shortly set out. Cacao, being a crop subject to cross-fertilization, will not breed true from seed, and although the seedling progenies of selected trees should be well above the average in performance, they cannot be expected to prove uniform, either in yield or in qualitative characters. Lack of uniformity in yield means loss on all those trees which are inferior to their parent, very doubtfully balanced by the chances of a few trees being superior. Lack of uniformity in other characters detracts seriously from quality, because uniformity is itself perhaps the greatest single factor in quality from the manufacturers' point of view. Uniformity in the field, with a crop like cacao, can only be obtained by some method of vegetative propagation.

This is only one aspect of the matter, and another possibly even more important at the present stage is that field experiments of any kind, leading to further knowledge, are particularly difficult when the reaction of each tree to experimental treatments varies from the reaction of its neighbours, and this must happen with seedling cacao. There is therefore a definite and economic need for vegetatively propagated cacao for experimental use, quite apart from its probable advantages in plantation practice.

One method of vegetative propagation is ready to hand in the budding of selected types on to seedling stocks. It has been shown that this method reduces the variability of the population in bearing capacity (1933 Report) and in some characters it naturally removes it altogether. It is not, however, ideal because the stocks themselves vary and induce variation in behaviour of the scions. For scientific investigations, therefore, it is highly desirable to have stocks also propagated vegetatively. This is the fundamental reason for research into new methods, but we have always had in mind the probability that new methods will benefit the grower directly as well as indirectly.

In 1930 the whole range of horticultural practice with other crops was open for investigation as to applicability to cacao. The first year's work narrowed down the issue and showed that softwood (or more strictly semi-hardwood) cuttings could be successfully rooted and afforded the most promising means to the desired end (1931 Report). In the following year the technique was improved (1932 Report) and at present we are rooting cuttings in considerable numbers for projected field experiments with the method reduced practically to routine, though there is still room for improvement. The rooting habits of the two kinds of branches that cacao trees bear have been compared (1933 Report), and the possibility of converting one kind of branch into the other has been established (1933 Report). These successes, though less spectacular than the results of genetic selection, are nevertheless real and important advances in the study of the cacao tree. They render possible comparisons of the selected trees which could not otherwise be undertaken, and they open up an enormous field of future researches which depend for their prosecution on the provision of absolutely uniform sets of trees.

Whether selected trees should be propagated on their own roots, as cuttings, or budded on to vegetatively raised stocks for the best commercial results remains to be shown in the field trials mentioned above.

Studies of Fruitfulness.

Studies of fruit setting and development are directed towards improvement of yields from established cacao no less than towards finding the best conditions for the new types that we hope will form the plantations of the future.

The most important information obtained concerns pollen compatibility, and goes far to explain the irregularities in fruit setting which are a prominent feature of the cacao crop. It was shown quite early that certain trees consistently gave poor setting from self-pollination, though they set freely when crossed with pollen from other trees (1931 Report). More extended observation showed that this self-incompatibility was widespread in Trinidad cacao, and further that there was a close connection between self-compatibility and setting, so that it is often possible to tell which trees are self-compatible and which self-incompatible by observing which are setting fruit naturally and which are not. Self-incompatible trees will set on crossing, and the fact that at many times they set little or nothing indicates that cross pollination at those times is very little in amount (1932 Report). Later it was shown that a self-incompatible condition is not necessarily permanent, but that under appropriate conditions some (perhaps all) self-incompatible trees may become self-compatible. When that happens, the tree begins to set fruit where it has formerly been almost or entirely barren (1934 Report). Work along a parallel line had meanwhile shown that plantation trees can be divided into continuous setters, fruiting

steadily through most of the season, and intermittent setters, and that the former give a much higher total yield than the latter (1932 Report). It is now evident that the continuous setters are the trees continuously self-compatible, and the problem becomes one of determining the conditions that favour maintenance of a self-compatible condition.

There is weighty evidence for the view that self-compatibility is influenced by nutrition, and this line of work brings us into close association with the activities of the Chemical Section. In collaboration with that Section and with the Trinidad Department of Agriculture a field experiment has been laid out to investigate the gross effects of mineral nutrition (applications of nitrogen, potash and phosphoric acid) on setting and fruit development, and the first results on analysis indicate that much useful information will be derived in future years (1934 Report).

Other aspects of fruitfulness that have been considered concern the pollinating agents and the heavy percentage of young fruits that commonly shrivel in the early stages of development. Advances along these lines have not been very important, but the work on compatibility goes to show that both of them are probably subordinate to setting as factors in final yield. Inefficiency of cross-pollinating agents may limit yield on self-incompatible trees, but once the trees get into a self-compatible condition adequate self pollination seems to occur, though the agents are still somewhat obscure. If self-compatibility can be induced by appropriate treatment, the identification of pollinating agents will probably cease to have any economic significance, though it will still be an interesting scientific problem. The shrivelling of young fruits is undoubtedly a serious source of loss of crop on some trees, but appears to depend very largely on environmental factors beyond control. There would at present appear more hope of compensating this loss than of avoiding it altogether. The continuously self-compatible tree seems partially to avoid heavy loss by spreading its crop over a longer period, and probably compensates such loss as it does suffer, by setting a further crop when conditions for development improve. It is thus likely that the solution of the shrivelling problem will be found in the conditions governing self-compatibility. In any event it may justly be claimed that a much more coherent picture of fruitfulness in cacao has been drawn by these researches than was available before, though much remains to be investigated.

Other Researches.

Work not directly on the main lines discussed above has included (1) A preliminary study of inheritance of pigment in cacao beans, which bears on questions of quality (1933 Report). (2) Statistical examination of yield records kindly made available by the Trinidad Department of Agriculture, directed towards determining the size of plot and layout necessary in field experiments with cacao. (*Tropical Agriculture* 9. 1932. 277.) (3) Studies of viability of cacao beans after storage and transport, designed to facilitate exchange of planting material between countries (1934 Report). (4) Examination of cacao roots for evidence of mycorrhizal infection, bearing on the general physiology of the tree (1934 Report). These are technical matters which need not be further elaborated here, though they all help forward the general objects that have been outlined.

Outlook.

This summary will have failed in its purpose if it has not suggested certain possibilities for the future of the cacao industry. Our vision of the future is of uniform fields, producing at lower costs per bag at least twice the present number of bags per acre. The cacao may be of varying qualities appropriate to different districts or countries, but will be uniform in all botanical respects within districts or at least within fields. The yields will justify intensive treatment of the trees, and limitation of cultivation to the most suitable soils and sites. Intensive methods based on further studies of fruiting will tend to reduce the present wide fluctuations of yield with season. Uniform trees will allow better adaptation of type to manufacturers' requirements and will facilitate preparations of the beans for the market. The prospect is one of greater regularity and more stability for both planter and manufacturer, and is surely worth striving for. The researches reported show that all these improvements are well within the bounds of possibility so far as Trinidad is concerned, and we believe the same principles to be applicable to other producing countries subject only to differences of standard and of detail.

The ideal is unfortunately far ahead, and one criticism of our work is that its benefits will be reaped by another generation. Even if this were true, it would be a poor reason for abstaining from research, but as a fact it is far from the whole truth. Economic benefit may be reaped from long range research long before its ultimate objects are attained. There are progressive planters who have already begun to apply the information gained in these preliminary investigations, and their action is one of the greatest encouragements the research workers could receive. A gradual replacement of the worst and most unprofitable trees can be effected without appreciable reduction of yields, and it will not be many years before the new trees begin to bear. Pending further trials of propagation methods, replacement by budded or seedling progenies of selected trees is the best that can be done. If seedlings are used, they will not be uniform in yield or in quality, but they can hardly fail to show better average performance in both respects than the worthless types they replace. In a few years we hope to have better material for further replacements.

Meanwhile, improvements of yield resulting from studies of fruitfulness are likely to afford means of increasing returns from established trees, and the progress already made encourages the hope that definite results along that line need not be long delayed.

THE CHEMICAL AND ECOLOGICAL RESEARCHES ON CACAO.

F. HARDY, M.A.

(I) OBJECTS OF THE INVESTIGATION.

The main object of the chemical investigations of the cacao crop is to investigate thoroughly the environment in which the cacao tree is grown, with a view to determining what are the exact atmospheric and soi conditions most conducive to high production and good quality. When these conditions have been determined accurately, steps may then be taken to improve the growth conditions in fields where cacao production is unsatisfactory, and definite advice may be offered to planters, concerning those soils and localities which would appear to be most suitable for new cacao cultivations.

The subject was approached from two main points of view, namely, (1) systematic qualitative and quantitative studies of the soils and of the atmospheric environments of two contrasted "good" and "bad" plots of established cacao in Trinidad, and (2) detailed soil surveys, within the West Indies region, of representative cacao areas of determinable reputation and performance. These preliminary investigations revealed the chief characters of a good cacao soil; they also indicated the particular external factors that mainly confer high productivity, or contrarily, that seriously limit production. The information obtained from these preliminary broad lines of research naturally led, in due course, to other more detailed investigations, many of which are still incomplete. Field experiments were laid down which comprised a series of manurial trials and trials of organic mulches. The effects of manuring and mulching were assessed, not only by records of yield increments, but also by chemical analyses of the leaves and other parts of the cacao tree, and by a systematic study of the effects produced by the manuring on the physical and chemical properties of the soil. Striking responses to manurial treatment, and definite interactions between the three chief plant nutrient substances, nitrogen, phosphate and potash, were soon revealed, leading to a further series of general manurial trials, which are still being continued.

In the following sections, a brief outline is presented of the progress which has been made and the results obtained during the period under review.

(II) STUDIES OF THE ENVIRONMENT OF THE CACAO TREE.

For the purposes of this investigation, contrasted "good" and "bad" cacao plots were selected for close observation. The physical and chemical features of the soil of each plot, down to a depth of six feet, were determined, and in addition, routine measurements of the following fluctuating environmental factors were made:— (1) rainfall, (2) soil moisture, (3) level of soil water-table, (4) humidity of the air, (5) evaporating ability of the air at three different levels, (6) light intensity at three different levels, and (7) air and soil temperatures. Periodic observations were also made of the condition of the cacao trees with regard to vegetative flushing, flowering, setting of fruit and shedding of fruit.

These measurements and observation; were carried out for a period of three years. The results have been fully discussed in the first three annual reports on Cacao Research; they demonstrated the remarkable effects of fluctuations in the moisture conditions of the atmosphere and of the soil on the vegetative and reproductive processes of the cacao tree, and indicated that the most suitable environment for the cacao tree is one in which moisture fluctuations are least, thus proving the value of overhead shade and windbreaks in the cacao field. Apart from the intrinsic value of these findings, the results have important application in connection with other investigations, such as those concerning the effects of manurial and cultural treatments on the growth and yield of the cacao tree. Since the fluctuations in the moisture environment have thus been shown to exert a marked effect on the setting and production of the cacao crop, detailed measurements of soil and atmospheric moisture fluctuations accordingly have been made at the sites of the later manurial experiments and mulching trials. By this means, it should eventually be possible to distinguish clearly between seasonal and environmental effects on crop production, and between the different effects of the specific experimental treatments which are being tested.

(III) CACAO SOIL SURVEYS.

Soil surveys of important cacao-growing districts have been carried out, not only in Trinidad, but in the neighbouring West Indian islands, Tobago and Grenada. The methods by which these soil surveys have been conducted are briefly as follows: Sample pits are dug in selected sites, usually to a depth of six feet. The soil profile thus exposed usually shows marked stratification into more-or-less distinct but merging layers. The topmost layer is rich in organic matter derived from decaying vegetation; it has been found to be particularly important, since it contains the bulk of the nutrients on which the cacao tree thrives. The soil profile is described in field notes, and soil samples, representing the different layers, are collected for laboratory examination, usually about ten for each profile. In the laboratory, the following routine determinations are made by the analytical staff of the College Chemistry Department:—

(*a*) Reaction; degree of acidity or alkalinity; (*b*) Texture; degree of sandiness or clayiness; (*c*) Calcium carbonate (free lime) content; (*d*) Organic matter content; (*e*) Available water-soluble plant nutrients; (*f*) Total nitrogen; (*g*) Available phosphate; (*h*) Available potash.

During the course of the cacao soil surveys, profile samples have been obtained at 178 different sites, giving approximately 1,780 soil samples for analysis in the laboratory. For purposes of comparison, these sites were divided into "good" and "bad," depending on the recorded yields of the cacao trees. The conclusions concerning the characters of good cacao soils are thus based on the chemical analysis of a large number of soil samples taken from contrasted high-yielding and low-yielding areas. The experimental methods and results have been fully described in special reports*, and in the First, Second, Third and Fourth Annual Reports on Cacao Research. Many of the findings may be directly applicable in cacao-growing regions occurring in other parts of the world, since they appear to be fundamental, as well as peculiar to the cacao crop.

(IV) Physical and Chemical features of Good Cacao Soil.

(1) *Soil Reaction; Degree of Acidity or Alkalinity.*

The cacao tree appears to be tolerant of a wide range of soil reaction, the optimum reaction being slightly on the acidic side of neutrality. A highly acidic reaction occurring in heavy clay soils may be taken as a sign of physical conditions of the soil unsuitable for the growth of cacao.

(2) *Texture; Degree of Sandiness or Clayiness.*

One of the primary requirements of a good cacao soil is an even moisture status, that is, the soil must not dry out quickly, nor be subject to waterlogging during wet weather. Optimum texture conditions will therefore vary with climatic and environmental factors. Good natural drainage is essential, but light sandy soils are only suitable for the growth of cacao in well-sheltered moist environments.

(3) *Calcium Carbonate (Free lime) Content.*

The lime content of cacao soils does not appear to exert an important influence on their fertility, since productive cacao occurs both on calcareous and on non-calcareous soils. The exact rôle of calcium in cacao nutrition is not yet understood; it is at present being tested by a number of detailed experiments.

(4) *Organic Matter Content and Carbon/Nitrogen Ratio.*

High-yielding cacao soils generally have a high content of organic matter in their surface layers. The conservation of the surface layer of litter or decomposing vegetation appears to be a very important factor in the maintenance of high yields in West Indian cacao fields. Moreover, the ratio of carbon to nitrogen of this organic matter is generally much higher in the case of good yielding fields than in poor yielding fields.

(5) *Harmful Factors.*

In a number of clay soil-types occurring in Trinidad, poor growth and yield of cacao are often associated with a high content of the natural mineral, gypsum (soluble calcium sulphate), present in the sub-soil layers. This has led to the conclusion that excessive quantities of calcium sulphate in the soil may adversely effect the growth and yield of cacao. The exact manner in which this harmful effect takes place is not yet understood, but the matter appears to be of great practical importance, in view of the high sulphate content of commercial artificial manures, such as superphosphate (which contains 50 per cent. calcium sulphate), ammonium sulphate and potassium sulphate. A number of experiments have been designed, and are now being carried out, in order to discover the reason for the harmful effect of excessive sulphate on the cacao tree.

(6) *Total Nitrogen.*

West Indian cacao soils appear to be generally well supplied with nitrogen, no definite differences having been found between the nitrogen contents of high and of low yielding soils.

(7) *Available Phosphate.*

One of the most striking features revealed by the examination of West Indian cacao soils is a marked deficiency of available phosphate in the poorer types of soil. Conversely, high yielding soils generally have a high available phosphate content. Very few exceptions to this rule have been discovered, at least for the heavier kinds of cacao soil.

(8) *Available Potash.*

Adequate supplies of available soil potash are essential for the optimum growth and yield of the cacao tree. Certain sandy types of soil in Trinidad are markedly deficient in potash, but this condition is not nearly so widespread as phosphate deficiency in the areas so far surveyed.

(9) *General Nutrient Status of West Indian Cacao Soils.*

The evidence obtained from the soil investigations has revealed an *unbalanced* nutrient supply in the less-fertile cacao soils of the areas so far surveyed. Nitrogen appears to be present in these soils in adequate amounts relative to phosphate and potash. This circumstance may be due partially to the customary practice of planting leguminous shade trees in the cacao fields, thereby subjecting the soil to continuous

* Studies in West Indian Soils; (III) Cacao Soils of Tobago; (IV) Cacao Soils of Grenada; (VII) Cacao Soils of Trinidad, (A) Montserrat District, by F. Hardy, J. A. McDonald, G. Rodriguez, *et al.*, Reports published by Editorial Department, Imper. Coll. Trop. Agric., Trinidad, in 1931, 1932 and 1933.

mulching with highly nitrogenous material, consisting of leaves, flowers and twigs dropped from the shade trees. The shade trees often grow to the size of large forest trees; they must take up considerable quantities of plant nutrients from the soil. Being leguminous, they are able to manufacture their own nitrogen supply, but they are wholly dependent on the soil for their supplies of phosphate and potash. Thus they may deplete the soil of cacao fields of phosphate and potash relative to nitrogen. Whatever the causes of the condition, it is now definitely established that many West Indian cacao soils are suffering from a lack of balance in their nutrient supply. From a practical point of view, therefore, full benefit cannot be expected from the application to the soil of haphazard or arbitrary manurial mixtures. The common practice of using general "complete" manures may be particularly wasteful, since one of the ingredients of the complete manure may already be present in the soil in adequate or even excessive amounts relative to the other nutrients. Improvement of yield by means of manuring must consist of applying nutrient substances in correct proportion, so that the nutrient balance of the soil may be restored.

(V) Manurial experiments on Cacao in Trinidad.

A number of field manurial trials were initiated at the beginning of 1932, in order to test some of the main findings of the detailed soil investigations. The first series of field experiments solely concerned the phosphate factor, since deficiency of this nutrient appeared to be the most serious factor limiting crop production. Other field experiments were subsequently laid down to test (*a*) the comparative effect of different types of phosphatic manure, (*b*) the effect of organic matter, (*c*) the effect of nitrogenous, phosphatic and potassic manures, both alone and in combination, and (*d*) the comparative effect of artificial manures on shaded and un-shaded cacao. The results so far obtained are presented in detail in the Fourth Annual Report on Cacao Research. The preliminary results have shown that very striking improvement in the yield of established cacao may be obtained by the proper use of artificial manures that rectify known nutrient deficiencies. On certain phosphate-deficient soils, yield increases of over one hundred per cent. have been obtained by the use of superphosphate manure alone, and within one year of the first application. A manurial experiment carried out by the Botanical Section on a potash-deficient soil, similarly gave large increases in yield from potash manuring. Such striking improvements in yield have not been confined only to quantitative increases, but evidence has been obtained that the use of artificial manures has improved the *quality* of the cacao produced, as shown by an increased size of bean. No direct evidence has yet been obtained, however, of the beneficial effect of organic mulches on the yield of cacao. Critical experiments with mulches necessarily require considerable time for completion, and the experiments have only recently been inaugurated. Certain other manurial matters still require investigation. For instance, for phosphate-deficient soils, further additional increases in yield may be obtained from potash and nitrogen manuring, provided the phosphate deficiency has first been remedied. Again, evidence has been obtained of a reciprocal relationship between potash and lime in cacao nutrition, and the requirements of the cacao tree for potassium may vary considerably depending on the calcium content of the soil. The possibly harmful effect of calcium sulphate, and the effect of artificial manures in the presence and absence of this substance, are also being studied by means of field experiments.

(VI) Pot Tests for Soil Fertility.

The chemical tests usually applied to determine the content of available plant nutrients in the soil sometimes give misleading results. This is due to the fact that plant nutrients are often present in the soil in a form unavailable to the plant, and chemical tests do not always clearly distinguish between available and unavailable nutrients. Accordingly agricultural research workers have lately developed a number of pot tests, which depend on the plant itself as a test of soil fertility. Investigations carried out in Trinidad on these lines in connection with cacao soils, have developed a sensitive pot test for assessing available phosphate contents. This test depends on the peculiar sensitivity of young tomato plants to phosphate deficiency, and it offers a simple method whereby the planter can test his soils for phosphate deficiency, without recourse to chemical procedures. The method has been fully described in an article published in *Tropical Agriculture*, Vol. X, No. 4, 1933, p. 108.

(VII) Chemical Analysis of Cacao Leaves.

A further contribution to the solution of the general question of the nutritional requirements of the cacao tree is being sought in the chemical analysis of leaf material obtained from trees growing in the plots of the various manurial experiments. This method aims at diagnosing nutritional deficiencies in the soil by a determination of the chemical composition of the ash of the leaves. Such a procedure has elsewhere yielded valuable results for other orchard crops, such as the apple, provided a satisfactory basis for comparison can be obtained. The results of these investigations are fully described in the Second, Third and Fourth Annual Reports on Cacao Research. The chemical composition of different parts of the cacao tree is evidently largely influenced by the nutrient supply in the soil, and the chemical analysis of cacao leaf tissue has proved to be a reliable guide to the manurial requirements of the crop. The proportion of nitrogen to potassium in the leaf appears to be a

valuable index of the condition of the tree, both with regard to yielding capacity and general vigour. Leaf analysis has indicated that somewhat unexpected results may follow when different manures are applied to a particular soil. Thus, in one experiment, the addition of superphosphate manure resulted, not only in an increased uptake of phosphate by the cacao tree, but also in an increased uptake of potash, although no potash manure was applied.

(VIII) Sand and Water Culture Experiments.

By growing plants in pure sand or water cultures, the amount of a particular nutrient substance available to the plant may be varied at will. This method has therefore been used to study the effects of deficiencies of various nutrient substances on the growth and appearance of young cacao plants.

Nutrient deficiencies often reveal themselves by characteristic symptoms affecting the appearance of the plant. Thus, a particular kind of leaf-scorch affects fruit crops grown in England under conditions of soil potash deficiency, and nitrogen-deficient soils often impart an unhealthy pale-green colour to the leaves of plants supported by them. In order to ascertain whether similar symptoms affect cacao, special water culture and sand culture experiments were initiated. Some striking preliminary results of this phase of the cacao investigations are presented in the Fourth Annual Report on Cacao Research. Definite leaf markings and growth characteristics have been demonstrated for potassium deficiency and nitrogen deficiency respectively. The practical utility of these findings lies in the possibility of diagnosing nutrient deficiencies in the field, merely by observing growth characteristics and leaf markings similar to those obtained in the sand cultures. The recorded symptoms of potassium deficiency and nitrogen deficiency are very distinctive and easily recognised; they should be particularly useful for field diagnostic purposes. Leaf scorch symptoms of potassium deficiency have been observed in the field where the soil is known by chemical tests to be deficient in available potash.

(IX) Future Outlook.

As a result the investigations above described, it is now possible to state with some degree of certainty whether a particular soil or a particular locality is suitable for the successful cultivation of productive cacao. Future investigations may develop newer and better methods for assessing the characters of soil and environment. The importance of this line of research is obvious, since the proper application of the results already obtained to cacao growing areas in other parts of the world will depend on the accurate determinations of soil and environmental characteristics in each particular area. For those areas where cacao has already been established, the detailed examination of soil and environment is an essential preliminary to any scheme which aims at the quantitative or qualitative improvement of the yield of cacao. Even when naturally high-yielding strains are available to planters, their successful exploitation in countries where soil and atmospheric conditions may vary very widely, will ultimately depend on proper field procedures, involving the provision of suitable shelter, shade, and drainage, and the choice and application of the right assortment of manures.

The results so far obtained from manurial experiments in Trinidad show that such detailed investigations are eminently worth while. The yield of established cacao may be more than doubled within one year by suitable manurial treatments in some instances, whilst the quality of the product may also be improved. Such striking increases in yield have been obtained simply by supplying nutrient substances which were shown by chemical tests to be deficient in the soil. There are many aspects of cacao production which remain to be investigated by chemical methods. In particular, further evidence is required on the effect of manurial substances on the *quality* of the product, and the possible difference in chemical composition of high and low quality cacao. The exact rôle of organic matter in cacao nutrition has still to be elucidated, and, from a more immediately practical viewpoint, the best and most economic types of commercial fertilisers must be identified. These and other problems are being investigated largely by means of field experiments, but also by means of sand culture experiments and laboratory investigations. Indeed, the three methods of attack are frequently applied to the same problem, since field experiments and sand culture experiments provide material for laboratory examination.

The field experiment takes prior place in the present and contemplated future researches for many reasons. For example, it gives quantitative evidence concerning the practical utility of a particular treatment suggested by more academic investigations, and secondly, it also provides, for detailed chemical examination, soil and plant material from areas or plots where accurate yield data are available. By such means, it is possible to correlate chemical characters of soil and plant with yield or quality of the cacao produced. These are only broad indications of the course of future researches; as time goes on, the results of existing investigations must inevitably present new problems, and show existing problems in a new light. The chemical researches so far have clearly demonstrated the important part played by environment and nutrient supply in building up the cacao crop, and have also demonstrated the practical possibility of improving the yield of cacao by the proper application of the results of field and laboratory investigations.

EFFECT OF MANURIAL TREATMENT ON GROWTH OF SUGAR-CANE.

I.—Early Tiller Formation of Plant Canes in Relation to Manurial Treatment. The Variety B.H. 10 (12).

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Introduction.

THERE are recorded in this paper measurements of the effect of manurial treatment with ground limestone, sulphate of ammonia, superphosphate of lime and sulphate of potash on the average number of tillers formed by a stool of plant canes of the variety B.H. 10 (12) during the first season's growth. The measurements were made at the beginning of the dry season of 1935 on the plots of two manurial experiments planted in the previous wet season.

The measurements are of importance in that they prove the need for generous manurial treatment if maximum tillering is to be obtained during the early life of the plant. They show that under certain conditions the number of tillers to the stool can be increased threefold provided that the necessary information has been obtained by carefully devised manurial experiments in the field. The measurements also show that tiller formation is very sensitive to type of manurial treatment; that the effect of manures when applied in combination can differ very greatly from the sum of their effects when applied alone; and that the benefits to be derived from manuring can be in great part lost unless a very thorough study has been made of the influence of each manure in the presence of the others.

The first experiment described in this paper was laid down on a degenerated, one-time swamp and lagoon clay soil. The second experiment was laid down on a soil lighter in texture and of greater inherent fertility.

Details of the Experiments.

Experiment 1.

Date of Planting.—5th and 6th September, 1934.

Manurial Dressings.—The limed plots were dressed in 1930 with ground limestone at the rate of 10 tons to the acre, the average lime requirement of the soil. The plots treated with superphosphate were given ¾ oz. P_2O_5 to the stool at the time of planting and ¾ oz. P_2O_5 to the stool when the banks were broken. The plots which received sulphate of potash were given 1½ oz. K_2O to the stool at planting and 1½ oz. K_2O to the stool when the banks were broken. There were four sizes of dressing to the stool with sulphate of ammonia N_0, N_1, N_2, and N_3.

N_0—No sulphate of ammonia.

N_1—½ oz. of sulphate of ammonia at planting, and 1½ oz. at the breaking of banks.

N_2—1 oz. at planting and 3 oz. at the breaking of banks.

N_3—1½ oz. at planting and 4½ oz. at the breaking of banks.

In this experiment a dressing of 1 oz. to the stool is equivalent to 1.2 cwts. to the acre.

Date of Breaking of Banks.—The last week in November.

Design of the Experiment.—The dressings of lime, phosphate and potash were combined in every possible way with the four dressings of nitrogen. The 32 combinations thus obtained were separated into two pairs of 16 in a manner such that every combination of manures three at a time appeared once in each pair. This separation into two pairs of 16 treatments is possible in three alternative ways. These various alternatives were used to form the three pairs of randomised half-blocks, of 16 plots to each half-block, on which the measurements were made. A list of the 32 different treatments, the manner of their distribution in the half-blocks, a plan of the experiment, and the previous manurial history of the plots, have been published in the *Proceedings of the Sugar Cane Investigation Committee of Trinidad* (Vol. III, part XVIII, page 54, 1930; Vol. IV, part VI, page 395, 1934).

Dates of Measurements.—The tiller counts on one pair of half-blocks were made between 4th and 9th January, 1935. The counts were made on the other two pairs of half-blocks between 11th and 16th January, 1935.

Experiment II.

Date of Planting.—31st August, 1934.

Manurial Dressings.—There were two dressings of sulphate of ammonia (N_1 and N_2), of superphosphate (P_0 and P_1) and of sulphate of potash (K_0 and K_1). The N_1 plots and the N_2 plots were given 2 cwts. of sulphate of ammonia to the acre at the breaking of banks. The N_2 plots were given, in addition, one cwt. of this manure to the acre at planting. The P_1 and K_1 dressings were 2 cwts. of superphosphate and 2 cwts. of sulphate of potash to the acre, respectively, applied at the breaking of banks.

Date of Breaking of Banks.—22nd October, 1934.

Design of the Experiment.—The two nitrogen dressings were combined with each phosphate dressing to give the plot treatments N_1P_0, N_1P_1, N_2P_0 and N_2P_1. The experiment was laid down in the form of five randomised blocks of six plots, the N_2P_0 and N_2P_1 treatments each being repeated twice in each block. All the plots were sub-divided into two, and one of each of the pairs of half-plots, chosen at random, was dressed with potash.

Date of Measurements.—The tiller counts in Experiment II were made between the 1st and 5th of February, 1935.

Rainfall on the Experimental Areas.

The rainfall on the two experimental areas during the periods between the time of planting and the second application of manures, and between the second application of manures and the date of the tiller counts, is recorded overleaf.

Rainfall in inches between time of planting and date of measurements.

Period.	Before second application of manures (31st Aug. to 22nd Oct.)		After second application of manures (22nd Oct. to 5th Feb.)				Total.
Month.	Sept.	Oct.	Nov.	Nov.	Dec.	Jan.	Feb.	
Experiment I.. ..	5.87	12.39	13.21	..	5.67	0.50	..	37.64
Experiment II.. ..	6.79	6.75	..	10.02	2.94	1.77	0.08	28.35

Methods of Measurement.

In both experiments two three-eyed setts were planted to the 'hole.' In such circumstances both setts sprout side by side in a manner which may make it impossible to differentiate between the two plants. No attempt was made at differentiation during measurement of the number of tillers, each pair of plants being considered to constitute a single stool.

In Experiment II it had previously been found that treatment with sulphate of ammonia at planting had no adverse effect on germination. The tiller counts were made on every stool in each half-plot, whether the stool was formed from the originally planted setts or from 'supply' setts. There were 78 stools to each half-plot.

In Experiment I it had been found that the dressing of ground limestone had a beneficial effect on germination, and that the inorganic manures applied at the time of planting had an adverse effect. In this experiment the tiller counts were made only on stools formed from the originally planted setts. The average number of tillers to the stool was not calculated from the total number of stools to the plot (130) but from the number of stools on which measurements were actually made. The number of supply setts required for the various plots of this experiment have been recorded in a previous paper (*Proceedings of the Sugar Cane Investigation Committee of Trinidad*, Vol. IV, part VI, page 404, 1934).

In view of the large number of stools on which counts were made a very accurate measure is possible of the relationship between number of tillers to the stool and manurial treatment, in both experiments.

The Effect of Manurial Treament on Tillering during the First Season's Growth.

The average number of tillers to the stool of cane on the variously manured plots of the two experiments is recorded in Table I.

(1) General Summary of Measurements.

Table I.—*Effect of manurial treatment on number of tillers to the stool.*

Experiment I.

Additional Treatment.	Treatment with Sulphate of Ammonia.			
	N_0.	N_1.	N_2.	N_3.
Nil	3.43	6.10	6.33	10.17
Lime	9.03	10.57	9.97	10.10
Phosphate ..	4.93	8.17	8.90	8.13
Lime and phosphate	7.07	10.93	9.63	10.47
Potash	5.10	7.83	9.53	8.03
Lime and potash ..	8.50	10.87	11.73	13.27
Phosphate and potash ..	4.30	6.20	8.97	11.30
Lime, phosphate and potash ..	7.40	11.87	11.87	12.70

Each figure in the table above is the mean for approximately 350 stools.

In Experiment I the use of a manure containing lime, high nitrogen and potash increased the average number of tillers to the stool from 3.4 to 13.3.

Experiment II.

Sub-treatment.	Main treatment.			
	N_1P_0	N_2P_0	N_1P_1	N_2P_1
K_1 ..	9.68	10.17	10.32	10.87
K_0 ..	9.73	9.59	9.62	9.31

The figure for each N_1 sub-plot is the mean for 390 stools. The figure for each N_2 sub-plot is the mean for 780 stools.

In Experiment II treatment with phosphate, potash and an additional light dressing of nitrogen increased the average number of tillers to the stool from 9.6 *to* 10.9.

(2) The Direct Effects of Limestone, Nitrogen, Phosphate and Potash on Tillering.

The average direct effects on the number of tillers to the stool of lime, nitrogen, phosphate and potash are recorded in Tables II to V.

(*a*) *Limestone*

Table II.—*Average effect of ground limestone on number of tillers.*

Experiment I—(Mean values for 5,600 stools).

Dressing of ground limestone.	Number of tillers per stool.
10 tons per acre ..	10.37
Nil	7.34
Increase due to limestone	3.03
Percentage increase ..	41 per cent.

Previous treatment of the soil with ground limestone has resulted in a large average increase in the number of tillers to the stool. The increase might be due to chance far less than once in 100 times.

(*b*) *Sulphate of Ammonia.*

Table III.—*Average effect of sulphate of ammonia on number of tillers.*

Experiment I.—(Mean values for 2,800 stools.)

Treatment with S/A.	N_0.	N_1.	N_2.	N_3.
No. of tillers per stool	6.22	9.07	9.62	10.51
Increase due to S/A	..	2.85	3.40	4.29
Percentage increase	..	46	55	69

In this experiment the average number of tillers to the stool increases largely as the dressing of sulphate of ammonia is increased. The effect of the sulphate of ammonia might be due to chance far less than once in 100 times.

Experiment II.

Treatment with S/A per acre.	Nil at planting 2 cwts. later (Average for 1,560 stools).	1 cwt. at planting 2 cwts. later (Average for 3,120 stools).
No. of tillers per stool ..	9.83	9.99
Increase due to priming dose of S/A ..	—	0.16

The influence of the priming dose in Experiment II is very small and not significant. *It will be seen later, however, that this early dressing of sulphate of ammonia can have a very important and significant effect on the number of tillers to the stool when a later dressing of potash also is applied.*

(*c*) *Superphosphate.*

Table IV.—*Average effect of superphosphate on number of tillers.*

Experiment.	I (5,600 stools).		II (2,340 stools).	
Treatment with superphosphate	P_0	P_1	P_0	P_1
Number of tillers per stool	8.79	8.93	9.81	10.05
Increase due to phosphate ..	..	−0.14	..	+0.24

The average effect of superphosphate is not significant in either experiment. It will be seen later that *the effect of superphosphate can become of importance in the presence of other manures* (Tables VIII, IX, XI and XII).

(*d*) *Sulphate of Potash.*

Table V.—*Average effect of sulphate of potash on number of tillers.*

Experiment.	I (5,600 stools).		II (2,340 stools).	
Treatment with potash ..	K_0.	K_1.	K_0.	K_1.
No. of tillers per stool ..	8.37	9.34	9.53	10.33
Increase due to potash ..	..	0.97	..	0.80
Percentage increase	..	11.6	..	8.4

In both experiments treatment with sulphate of potash increases the number of tillers to the stool to an extent which might be due to chance less than once in 100 times.

(3) First Order Interactions.

The average effects on the number of tillers to the stool of the manures lime, nitrogen, phosphate and potash when applied in pairs, are recorded in Tables VI to IX.

(*a*) *Limestone and Sulphate of Ammonia.*

Table VI.—*Average effect of increasing dressings of S/A, in the presence and absence of ground limestone, on number of tillers to the stool.*

Experiment I.—(Mean values for 1,400 stools.)

Treatment with S/A.	N_0.	N_1.	N_2.	N_3.
Limed plots	8.00	11.14	10.80	11.63
Unlimed plots ..	4.44	7.08	8.43	9.41
Increase due to limestone	3.56	4.06	2.37	2.22
	3.81		2.30	

On both the limed and unlimed plots there is a significant increase in the average number of tillers to the stool as a result of treatment with sulphate of ammonia. *On the limed plots the increase appears to be independent of the size of the dressing of nitrogen, attaining its maximum in the region of the lowest dressing* (N_1). *On the unlimed plots the number of tillers to the stool increases as the size of the dressing of nitrogen is increased, in accordance with the law of diminishing returns. A maximum is not reached even with the highest dressing of nitrogen* (N_3). This dependence of the effect of size of dressing of nitrogen on the presence or absence of limestone might be due to chance less than once in 100 times. A parallel interaction of limestone with nitrogen has been recorded for yield of cane (*Proceedings of the Sugar Cane Investigation Committee of Trinidad*, Vol. IV, part V, page 315, 1924).

It is worthy of note that although dressings of nitrogen and lime in combination lead to the formation of a greater number of tillers to the stool than either manure alone, the average increase in the number of tillers due to lime is significantly less on the high-nitrogen (N_2 and N_3) plots (2.30) than on the low-nitrogen (N_0 and N_1) plots (3.81). It will be shown later (Table X) that the effect of lime on tillering in relation to the size of the nitrogen dressing is dependent on the presence or absence of potash.

(*b*) *Sulphate of Ammonia and Sulphate of Potash.*

Table VII.—*Average effect of increasing dressings of S/A, in the presence and absence of potash, on number of tillers to the stool.*

Experiment I.—(Mean values for 1,400 stools.)

Treatment with S/A.	N_0.	N_1.	N_2.	N_3.	Mean value for N_1, N_2 and N_3 plots.
Plots with potash ..	6.33	9.19	10.53	11.33	10.35
Plots without potash	6.12	9.03	8.71	9.72	9.15
Increase due to potash	0.21	0.16	1.82	1.61	1.20

In both the presence and absence of potash there is a significant increase in the number of tillers to the stool due to treatment with nitrogen. *In the presence of potash the increase follows the law of diminishing returns and a maximum is not reached even with the heaviest nitrogen treatment* (N_3). *In the absence of potash the maximum is obtained in the region of the lowest dressing of nitrogen* (N_1). This difference in effect of size of dressing of nitrogen in the presence and absence of sulphate of potash is definitely significant. A parallel interaction of nitrogen with potash has been recorded for the yields of the crop reaped on the plots of Experiment I in the previous year.—(*Proceedings of the Sugar Cane Investigation Committee of Trinidad*, Vol. IV, part V, page 318, 1934).

It will be noted that *there is an essential difference in the nature of the interactions of lime with nitrogen and of potash with nitrogen.* In the former interaction a maximum number of tillers is obtained with the low dressing of sulphate of ammonia (N_1) in the presence of lime, and a maximum is not reached in the absence of lime. In the interaction with potash this state of affairs is reversed. Further, in the absence of potash the average increase in the number of tillers due to nitrogen (3.03) is significantly smaller than the average increase in the presence of potash (4.02). Under the average conditions which obtain on the experimental area, *treatment with potash enables the plant to make more effective use of the higher dressings of nitrogen, whereas treatment with lime results in a somewhat less effective use by the plant of the higher dressings of nitrogen.*

It is shown later that phosphate can profoundly modify the relative effect of potash, in the presence of high and low nitrogen, on the number of tillers to the stool.

EXPERIMENT II.

Treatment with S/A.	Nil at planting, 2 cwts. later (780 stools).	1 cwt. at planting, 2 cwts. later (1,560 stools).
Plots with potash ..	9.96	10.52
Plots without potash ..	9.68	9.45
Increase due to potash ..	0.28	1.07

It is clear from the data in this table that under the conditions which obtain in Experiment I I the effect of the priming dose of sulphate of ammonia is of extreme importance in the presence of potash although its effect is negligible in the absence of potash. This difference in behaviour of the priming dose in the presence and absence of potash might be due to chance less than once in 100 times.

It is of interest that the potash was added some seven weeks *after* the priming dressing of sulphate of ammonia. This would suggest luxury consumption of nitrogen by the plant, *i.e.*, the nitrogen may have been absorbed by the plant and stored unused until adequate potash became available.

(*c*) *Superphosphate and Sulphate of Potash.*

TABLE VIII.—*Average effect of phosphate and potash, alone and in combination, on number of tillers to the stool.*

EXPERIMENT II.—(Mean values for 1,170 stools.)

Treatment with Phosphate.	P_0.	P_1.
Plots with potash	9.98	10.68
Plots without potash ..	9.64	9.42
Increase due to potash ..	0.34	1.26

In the absence of phosphate the increase in the number of tillers to the stool due to potash is 0.34, whereas in the presence of phosphate the increase is 1.26. This interaction of phosphate with potash might be due to chance about once in 100 times in Experiment II. *Under the average conditions which obtain on this experimental area, therefore, treatment with phosphate is necessary for potash to exert maximum effect on tillering.*

Treatment with phosphate, in the absence of applied potash, results in a decrease in the number of tillers to the stool from 9.64 to 9.42. On the other hand, the dressing of phosphate, in the presence of potash, increases the number of tillers from 9.98 to 10.68. *The use of superphosphate therefore can be definitely adverse to tillering unless adequate potash is present.* Data obtained in other experiments give rise to a parallel conclusion in respect to yield of cane (*Proceedings of the Sugar Cane Investigation Committee of Trinidad*, Vol. IV, part I, page 31, 1934; Vol. IV, part II, page 132, 1934).

The interaction of phosphate with potash is not significant in Experiment I. It will be shown later that the interaction is dependent on the supply of available nitrogen (Table XII). It seems probable that the average level of available nitrogen in the soil of Experiment I, is not sufficiently high for the interaction of potash with phosphate to obtain.

(*d*) *Limestone and Superphosphate.*

TABLE IX.—*Average effect of phosphate on the increase in number of tillers to the stool resulting from liming.*

EXPERIMENT I.—(Mean values for 2,800 stools.)

Treatment with Phosphate.	P_0.	P_1.
Limed plots	10.55	10.24
Unlimed plots	7.07	7.61
Increase due to limestone ..	3.48	2.63

In the absence of phosphate ground limestone increases the number of tillers to the stool by 3.48. In the presence of phosphate this increase is reduced to 2.63 tillers to the stool. The depression in the increase might be due to chance about once in 20 times. It will be seen later that this adverse effect of phosphate can be neutralised in part by potash (Table XI).

(*e*) *Limestone and Sulphate of Potash.*

The interaction of limestone with sulphate of potash is not significant, *i.e.* the increase in the number of tillers to the stool due to lime is the same on the plots with potash as without potash (Table XI), and the increase due to potash is independent of the presence of lime. The effect of the two manures in combination may be taken as equal to the sum of their independent effects.

(*f*) *Sulphate of Ammonia and Superphosphate.*

This interaction is discussed later in this paper in connection with the data recorded in Table XII.

(4) Second Order Interactions.

The average effects on the number of tillers to the stool of the manures lime, nitrogen, phosphate and potash, when applied three at a time, are recorded in Tables X, XI and XII.

(*a*) *Limestone, Sulphate of Ammonia and Sulphate of Potash.*

Table X.—*Average effect of potash on the increase in number of tillers to the stool due to limestone, in the presence of high and low nitrogen.*

Experiment I.

Treatment with Potash.	K_0.	K_1.
Difference in number of tillers per stool on limed and unlimed plots :		
(*a*) In presence of low nitrogen (N_0+N_1) ..	3.74	3.80
(*b*) In presence of high nitrogen (N_2+N_3) ..	1.65	2.93
(*a*) − (*b*)	2.09	0.87

It has been shown earlier in this paper (Table VI) that although lime and nitrogen in combination cause the formation of a greater number of tillers to the stool than either manure alone, the increase in the number of tillers due to lime is less on the high-nitrogen (N_2 and N_3) plots than on the low-nitrogen (N_0 and N_1) plots.

It can be seen from the data in Table X that in the *absence of potash* the gain in number of tillers due to lime falls from 3.74 in the presence of low nitrogen to 1.65 in the presence of high nitrogen, whereas, in the *presence of potash* the corresponding fall is from 3.80 to only 2.93. Although the fall is not completely counteracted it is significantly arrested by the dressing of potash. Possibly, the dressing of potash is not large enough completely to neutralise the fall. *In any case it appears necessary to apply potash with limestone and sulphate of ammonia to get maximum tiller formation. It would seem that the plant is unable to make as effective use of high nitrogen on the limed plots as on the unlimed plots for the purpose of tiller production unless adequate potash is applied.*

In Experiment I the average number of tillers to the stool on the plots dressed with lime and high nitrogen (N_2 and N_3) is 10.4. If potash also is applied the number becomes 12.39.

A parallel interaction of potash with limestone and nitrogen has been obtained for yield of cane in other experiments in Trinidad (*Empire Journal of Experimental Agriculture*, Vol. II, No. 5, page 89, 1934.)

(*b*) *Limestone, Superphosphate and Sulphate of Potash.*

Table XI.—*Average effect of phosphate on the increase in number of tillers to the stool due to limestone, in the presence and absence of potash.*

Experiment I.

Treatment with Phosphate.	P_0.	P_1.
Difference in number of tillers per stool on limed and unlimed plots :		
(*a*) In presence of potash ..	3.46	3.27
(*b*) In absence of potash ..	3.54	2.00
(*a*) − (*b*)	−0.08	+1.27

It has been shown in Table IX that phosphate can adversely effect the gain in number of tillers to the stool due to liming. It is clear from the data set out in Table XI that this adverse effect is dependent on the supply of potash.

In the *absence of potash*, the increase in the number of tillers due to lime is reduced by phosphate from 3.54 to 2.00. In the *presence* of potash the increase is reduced from 3.46 to 3.27., *The potash has significantly, but not completely, counteracted the adverse effect of phosphate on lime.*

If no phosphate is applied the increase in the number of tillers to the stool due to lime is the same on the plots with potash as the plots without potash (Table XI), *i.e.* the lime exerts its particular effect independently of potash, and the effect of the two manures in combination is the sum of their effects when applied to separate plots. If phosphate is applied in addition, the net result is somewhat to reduce the total beneficial effect of the lime and potash.

The average number of tillers to the stool is 11.09 on the plots dressed with limestone and potash, and 10.78 on the plots dressed with limestone, phosphate and potash.

The yield data for the crop reaped in the previous year on the plots of Experiment I show an interaction of phosphate with lime and potash similar in type to that recorded in Table XI for number of tillers to the stool (*Proceedings of the Sugar Cane Investigation Committee of Trinidad*, Vol. IV, part V, page 317, 1934).

(*c*) *Sulphate of Ammonia, Superphosphate and Sulphate of Potash.*

TABLE XII.—*Average effect of phosphate on the increase in number of tillers to the stool due to potash in the presence of high nitrogen.*

EXPERIMENT I.

Treatment with Phosphate.	P_0.	P_1.
Difference in number of tillers per stool on high-nitrogen (N_2+N_3) and low-nitrogen (N_0+N_1) plots :		
(*a*) In presence of potash ..	2.56	3.77
(*b*) In absence of potash ..	1.86	1.51
(*a*) – (*b*)	0.70	2.26

According to the data set out in Table VII the effect on the number of tillers to the stool of high dressings of nitrogen (N_2 and N_3) is significantly increased by the presence of potash. The data recorded in Table XI make it evident that this effect of potash in the presence of high-nitrogen may be profoundly modified by phosphate. In the absence of phosphate the increase in the number of tillers to the stool due to potash, on the high-nitrogen plots relative to the low-nitrogen plots, is 0.70. In the presence of phosphate the increase due to potash is significantly augmented to 2.26. *In order that potash may exert its full effect on tillering in the presence of high nitrogen it appears that the presence of phosphate in adequate amount is essential.*

The difference in the number of tillers to the stool on the high-nitrogen plots and the low nitrogen plots in the absence of potash and phosphate is 1.86. Phosphate depresses the difference to 1.51 in the absence of potash, but increases the difference to 3.77 in the presence of potash. *These data provide confirmatory evidence of the unwisdom of applying phosphate in the absence of potash when heavy dressings of nitrogen are used.*

Experiment II was not designed to investigate with any special degree of accuracy the interaction of phosphate with nitrogen and potash.

(5) THIRD ORDER INTERACTIONS.

Limestone, Sulphate of Ammonia, Superphosphate and Sulphate of Potash.

As far as the three manures limestone, superphosphate and sulphate of potash are concerned, a greater number of tillers appear to be formed to the stool during the early life of the plant by applying lime and potash only, and by omitting phosphate. As far as the three manures sulphate of ammonia, superphosphate and sulphate of potash are concerned, definite gain results by applying phosphate with nitrogen and potash. There remains to be determined the net effect of phosphate when applied in addition to lime, nitrogen and potash.

A decisive answer to this question cannot be obtained from the data recorded for Experiment I. It is practically impossible conclusively to measure the significance of the interaction of any one manure with three others in a general experiment of this kind. To obtain an accurate estimate of the effect of phosphate in the presence of lime, nitrogen and potash, a separate and specially designed experiment is necessary.

Summary and Conclusions.

(1) There are recorded in this paper measurements of the effect on the number of tillers formed to the stool of the variety B.H. 10 (12), during its early life, of treatment with the manures limestone, sulphate of ammonia, superphosphate and sulphate of potash, when applied separately, in pairs and three at a time. The measurements show that tiller formation is very sensitive to manurial treatment.

(2) Under the conditions which obtained on the experimental areas it is shown that :—

(*a*) The number of early tillers formed by a stool of plant canes on the average can be increased by 40 per cent. by treatment of the soil with ground limestone, by as much as 70 per cent. with sulphate of ammonia, and by 10 per cent. with sulphate of potash. Phosphate appears to be of importance only in the presence of other manures.

(*b*) Dressings of lime and nitrogen in combination lead to greater tiller formation than either manure alone, but the average increase in the number of tillers due to lime is significantly less in the presence of high dressings than of low dressings of nitrogen. To obtain maximum tillering in the presence of lime and high nitrogen, treatment with potash is required in addition.

(*c*) Dressings of lime and potash, when applied together, both appear to exert their own independent effects on tillering.

Phosphate depresses the effect of lime on tillering, but this adverse effect of phosphate can be in part counteracted by treatment with potash.

As far as the three manures, lime, phosphate and potash are concerned, greater gain in tillering appears to result from applying lime and potash only, than from applying phosphate with lime and potash.

(*d*) The effect of high nitrogen and potash, when used together, is greater than the sum of their independent effects.

Phosphate can profoundly increase the average beneficial effect of potash in the presence of high nitrogen.

As far as the three manures nitrogen, phosphate and potash are concerned, much greater gain results from applying phosphate with high nitrogen and potash, than from applying high nitrogen and potash only.

(*c*) A definite need is shown to exist for accurate measurement of the effect of phosphate in the presence of the three manures, lime, nitrogen and potash.

(3) The measurements recorded were made on the plots of two field experiments. In the first of these experiments the use of a manure containing lime, nitrogen and potash increased the average number of tillers to the stool from 3.4 to 13.3. In the second experiment, phosphate, potash and an additional light dressing of nitrogen increased the average number of tillers to the stool from 9.6 to 10.9. The soil of the latter experiment is more fertile than that of the former. In addition, all plots of the second experiment received a basal dressing of nitrogen.

(4) There is evidence that in general a close parallelism exists between the number of tillers formed to the stool of plant cane, during its early life, and the ultimate yield of cane which is obtained.

Acknowledgments.

The data recorded in Table I were obtained from a field experiment which is partly financed by Imperial Chemical Industries, Ltd.

Appendix.

A list of the manurial interactions in relation to the number of tillers to the stool, which have been investigated in this paper, and the statistical significance of these interactions, is recorded below.

Manurial Interaction.	Value of P.	
	Experiment I.	Experiment II.
Direct :		
Lime ..	Less than 0.01	..
Nitrogen ..	Less than 0.01	N.S.
Phosphate ..	N.S.	N.S.
Potash ..	Less than 0.01	Less than 0.01
First Order :		
Lime with nitrogen ..	Less than 0.01	..
Lime with phosphate ..	0.05	..
Lime with potash	N.S.	..
Nitrogen with phosphate ..	N.S.	N.S.
Nitrogen with potash ..	Less than 0.05	Less than 0.01
Phosphate with potash ..	N.S.	Less than 0.01
Second Order :		
Lime, nitrogen, phosphate ..	N.S.	..
Lime, nitrogen, potash ..	Less than 0.05	..
Lime, phosphate, potash ..	Less than 0.05	..
Nitrogen, phosphate, potash ..	Less than 0.05	N.S.

If P is less than 0.01, the interaction might be due to chance less than once in 100 times. If P is less than 0.05, the interaction might be due to chance less than once in 20 times. N.S. denotes that the interaction is not significant.

If a direct interaction is significant, the effect of the manure on tillering is significant under the average conditions which obtain on the experimental area. If a first order interaction is significant, the effect of the two manures in combination differs from the sum of their independent direct effects. If a second order interaction is significant, the direct effect of one of the manures is profoundly modified by the presence of the other two.

REVIEW.

THE PINEAPPLE.

By Maxwell, O. Johnson, M.S., Ch.E. *Paradise of the Pacific Press*, Honolulu, 1935; pp. 306, 2 plates, 94 figures; price $5.00.

This is an excellent little treatise described by the author as "an attempt to compile and summarise the authoritative information on the pineapple". That he has managed to do this effectively and with commendable brevity, is sufficient proof of the quality of the work. All aspects of pineapple cultivation are included, starting with the early history and origin of the crop and finishing with a discussion on problems connected with canning and marketing the fruit. While the author writes from the research worker's viewpoint rather than that of the actual commercial grower, technical descriptions have been intentionally made as simple as possible so that the layman can pursue the book with interest and understanding, and obtain an accurate idea of the present state of our knowledge on all problems of any practical significance in pineapple culture. The illustrations are numerous and well-chosen, and add considerably to the value of the text.

Mr. Johnson has had some nineteen years' experience in pineapple research in Hawaii, and the technique evolved in that island naturally forms the basis of his conclusions. As Hawaii is probably the leading exponent of the application of modern methods to this particular crop, this is an advantage rather than the reverse. Brief descriptions are also given of the contrasting practices used in other countries that grow the pineapple on a commercial scale—South Africa, Florida, Cuba, &c. The bibliography is satisfactorily complete, and the experimental evidence on which conclusions are based is cited in the text. In addition to its other features the book is useful as a work of reference and from this aspect a second bibliography arranged according to subject matter might have been included with profit. To an English reader the use of the term 'fertilisation' in connexion with manurial requirements seems somewhat inappropriate. These are admittedly details of little significance, and really serve to show that in order to find fault, one requires to be hypercritical. This book is one that can be recommended with every confidence to all those interested in any way in the pineapple crop.

D. D. P.

AGRICULTURAL LABOUR IN TRINIDAD.—*Continued.*

By C. Y. Shephard.

Part V.—Remedial Measures.—*Concluded.*

The Cacao Industry.

In the cacao industry for over two hundred years, no attempt at a diversification of crops, for the purposes of increasing the financial stability, or equalising the seasonal demands for labour, of the estates, had been made; continued prosperity disguised the need for the former, and slavery and indentured immigration the need for the latter. These conditions no longer obtain; competition with other areas has rendered the financial prospects uncertain, while the emancipation of the slaves, and the cessation of indentured immigration, have thrown the industry into violent competition with others for labour.

Like sugar, and unlike short period annual crops, cacao affords some profitable employment throughout the year, but the labour requirements of the various operations differ greatly. The principal operations may be grouped conveniently under cultivation and reaping.* The relative importance of these two sections varies with the size of the estate and its location, the nature of the season, and its financial prospects. The following figures are based upon the records of 126 estates, representing 32,000 acres of cacao, during the period 1923-24 to 1929-30.

Cutlassing weeds and undergrowth absorbs 42 per cent. of the total units of labour employed in cultivation. While some cutlassing is done during every month of the year, particular activity is shown during the wet season from August to November. Trimming and pruning the trees, which accounts for another 26 per cent., commences immediately the main crop is over, in May, and continues until September, or even October. To avoid damaging the trees, this work is usually performed by skilled workers under careful supervision. Supplying cacao trees and shade takes place principally at the beginning, and towards the end, of the rainy season. Draining commences with, and continues throughout the wet season. Very little cultivation, with the exception of the necessary cutlassing, is done during the main crop season.

Reaping is very laborious, and consists of picking, gathering, heaping, and breaking the pods and extracting the beans which are "crooked", or carted, to the fermenting boxes. After having been fermented, the beans are sun-dried, polished, graded, bagged and despatched to the local market.

* For seasonal distribution of the principal operations on one estate (M.C.21) *see* Fig. 11.

Table 24.—Sub-divisions of Cultivation and Reaping.

Cultivation: (62 per cent. of total expenditure in labour).

	Per cent.
Cutlassing	42
Trimming and Pruning ..	26
Supplying Cacao and Shade ..	9
Draining	13
Miscellaneous	10
	100

Reaping, which is concentrated in the months December to March, combined with the essential cultural operations, results in the shortage of labour already noted. Unfortunately there appears no scope for the introduction of mechanical labour saving devices. The practice of "making work" during the slack periods, in order to retain labourers for the busy season, is one which can be adopted by few estates, and even by them within limits which fail to absorb all the available units of labour. There is, therefore, an urgent need for an additional crop which, in addition to increasing the financial stability of the estates, will enable them to employ labourers when the demands for cacao are small. The slump of 1921 led to some tentative efforts towards a diversification of crops, with the object of redressing the losses on cacao, but with little reference to minimising the seasonal fluctuations in employment.

Coffee, predominatly *Coffea arabica*, has been planted on a large number of estates, along the edges of the cacao fields, and between the cacao trees. Little separate cultural attention is required, with the exception of pruning, which takes place after the crop and during the dry season, generally in January. The principal demand for abour for *Coffea arabica* arises during the reaping season in November or December, and its effect upon the general labour situation depends upon the area under coffee, the size of the crop, and the periods during which the coffee, and the main cacao crops reach maturity. Few estates have extensive areas of bearing coffee though large areas are approaching maturity. On estate N.9, which possesses one of the largest mature areas, coffee absorbs only 11 per cent. of the total labour units, yet considerable difficulty is experienced in reaping both the coffee and cacao crops. The beans, which ripen irregularly over a period of four to six weeks, fall as they become ripe and these two factors complicate reaping. During 1926-27, the coffee ripened late, being reaped during December and January, and

required so many labourers that part of the cacao crop was lost. In 1927-28, the coffee crop which matured in November, was so small that it did not seriously interfere with the reaping of the cacao crop, which commenced in the same month. During 1928-29 coffee ripened in December and resulted in the loss of some of the cacao crop which began early.*

Although this estate is a large one, employing the equivalent of 1,512 men-days four weekly during the three years 1926-1928, and the owner is unencumbered, and commands exceptionally large financial resources, the standard deviation of the four-weekly units of labour for 1926 to 1928 was 17 per cent. The owner recognises that coffee and cacao in combination necessitate an elastic supply of labour which he is attempting to secure for the coffee reaping season from a village seven miles distant. Although desirable as a means of diminishing financial fluctuations, *Coffea arabica* complicates, rather than alleviates the problem of absorbing all the available units of labour. As the areas under coffee reach the bearing stage, their influence in accentuating the shortage of labour during the cacao reaping season will increase. Additional expensive drying sheds will also be necessary as they are required by both crops at the same time.

More recently *Coffea robusta* (or *Laurentii*) has been planted instead of *Coffea arabica*. The fruits are borne in dense clusters, ripen almost simultaneously, and do not fall when ripe, so that reaping is less troublesome than with *Coffea arabica*. In spite of these advantages difficulty will probably be experienced in reaping this variety since it matures during the period January to March, when both labour and drying sheds are required for the cacao crop. Only very small areas are, at present, mature.

The coconut, of all the individual crops cultivated in Trinidad, affords the greatest regularity of employment.† Draining increases the demand for labour slightly above the average during the wet season, while the demand is a little below the average during the dry season. Unlike cacao or coffee there is no critical period during which the fruit must be reaped or lost. The nuts are allowed to fall as they become ripe, and pickers climb the palms only two, three, or four, times a year, and then largely for the purpose of removing dead vegetation. Provided measures are taken to prevent praedial larceny, the crop can be neglected, for short periods, while the labour is drafted to the sugar or cacao sections. Very few estates grow coconuts and cacao, or coconuts and sugar, in combination, and in all such cases one crop predominates to such an extent that the seasonal distribution of labour is characteristic of it.

On estates C.P.S.5, and 18, where coconuts form a subsidiary crop, the sugar cane reaping season is eased by drafting labour from the coconut sections. Estate S.W.C.32 has 1,800 acres of coconuts in bearing and 100 acres of cacao. Although cacao is a much more laborious crop than the coconut, the cacao area is too small to cause any great increase in the labour units employed during its reaping season. The standard deviation of the units of labour employed four-weekly on this estate, during the three years 1925 to 1927, was less than four per cent., the units averaging 534. It may not be without significance that on this estate no shortage of labour was experienced throughout this period. Where conditions are suitable for the cultivation of coconuts in combination with either sugar or cacao greater regularity of employment can be offered, but such areas appear limited in extent.

Grapefruit has also been planted as a subsidiary crop to cacao but at present only about 35 acres are in bearing, while some 200 acres are immature. Several thousand acres at least are suitable for this crop (11), and the small mature areas suggest that costs of production are lower than in California, Florida, or South Africa. 'Marsh' is the principal variety cultivated. The fruit compares favourably in quality with other countries. The soils are inclined to be heavy and, apart from draining and pruning, the cultivation of the crop is in no way exacting, picking and packing being the most laborious operations. The fruit reaches picking stage from January to May, March and April, being particularly busy months. The fruit can be held on the trees for a short time after picking maturity has been reached. The early part of the picking season coincides with the main cacao crop and is likely to cause congestion of work. Labour also tends to be short towards the end of the grapefruit season so that this crop is not likely to solve the problem of providing regularity of employment.

Rubber, where it can successfully be grown in conjunction with cacao, offers the greatest possibility of reducing seasonal variations in employment. The history of this crop in Trinidad has been an unfortunate one, because opinion, as early as 1887, and for the succeeding twenty years was strongly in favour of *Castilloa elastica* (9) (10), About 3,000 acres were planted in this variety principally between 1896 and 1910 (1). J. B. Carruthers, who came from Malaya, arranged for the importation of two million *Hevea* rubber seeds from Malay in 1909-10 (14). As the result of his death, and the passing of the boon of 1910, interest in *Hevea* waned before any considerable area had been planted. *Castilloa* everywhere proved an expensive failure, and even *Hevea* was cut out or allowed to revert to bush.

Only 689 acres of *Hevea* remain, of which 522 are located near Sangre Grande, in the County of St. Andrew (2). From 1923 to 1927 rubber exports averaged 112,647 lb. per annum, valued at £10,045 (5). Few estates cultivate cacao and rubber in combination, the principal one being S.G.C. 35 (3), (13) which comprises 1,000 acres of cacao, 300 acres of rubber, 350 acres of coconuts,

* *See* Fig. 12. † *See* Fig. 13.

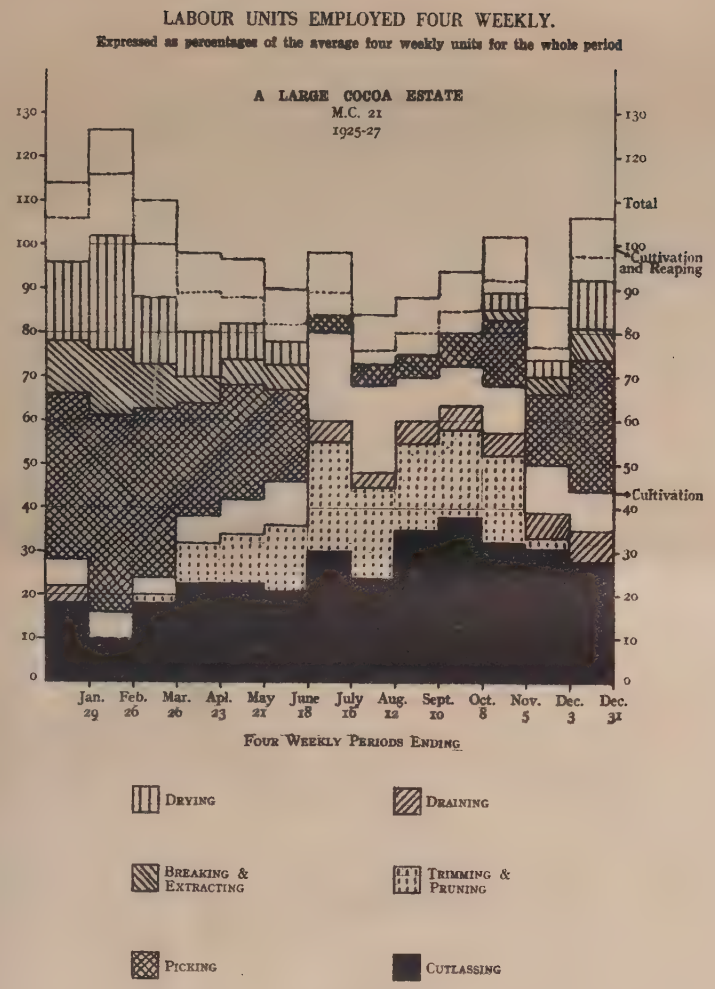

Fig. 11.—This estate is a large and well managed one. On smaller estates less cultivation is usually done and the contrast between the reaping season and the remainder of the year is consequently greater.

The blank spaces represent miscellaneous items too small to be shown separately. The difference between the total units and the aggregate absorbed by Cultivation and Reaping represents items of a capital nature or those which cannot be allocated to either of the main divisions.

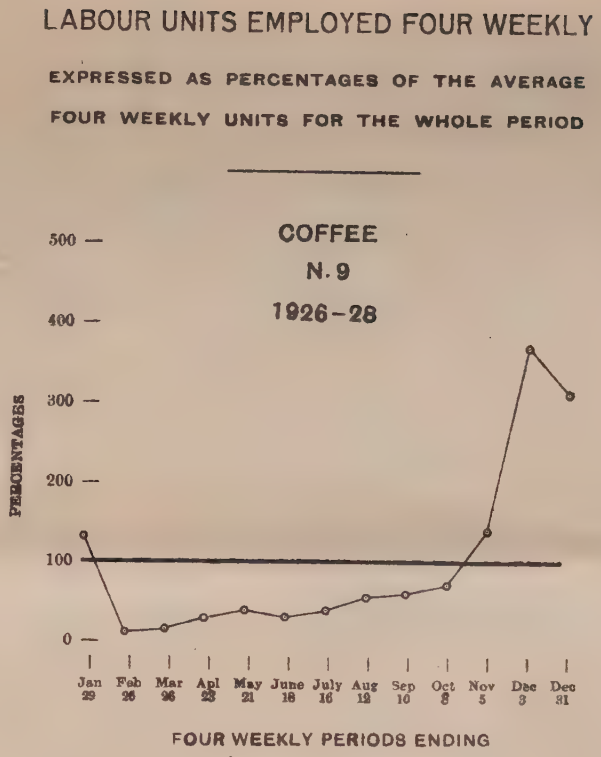

Fig. 12.—When coffee is cultivated in conjunction with cacao the demand for labour is principally confined to the reaping and pruning periods from November to January.

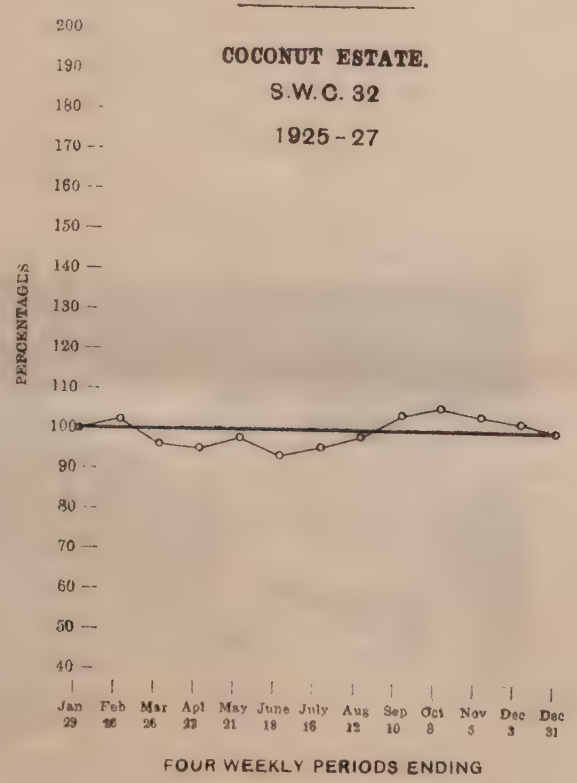

FIG. 13.—There is little seasonal variation in the demand for labour on a coconut estate. The slight rise during the wet season is due to draining.

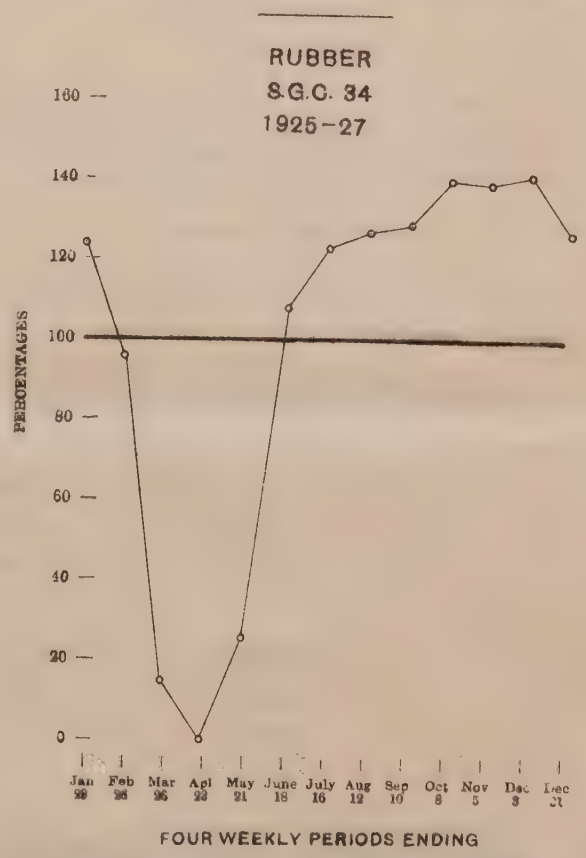

FIG. 14.—Tapping absorbs most of the labour units and continues throughout the wet, but ceases during the dry, season. This accounts for the heavy drop in employment from March to May.

and about 60,000 (mainly immature) coffee plants between the cacao trees. This estate produces about 65,000 lb. of rubber per annum. Rubber planting, between the cacao trees, commenced in 1905, and tapping in 1914. The original cacao trees have since been cut out, and rubber extended to areas too poor for cacao for which it serves as a windbreak. Rubber is a laborious crop requiring about three labourers to every four acres, tapping making particularly heavy demands. The trees are exposed by the change of leaf between the end of January and the latter part of May during which tapping ceases and the labour demands are negligible. Tapping continues throughout the wet season, when the labour demands of cacao are small, but can be stopped at any time without injury to the trees. The labourers employed on rubber are regarded as an emergency gang which can be drafted to cacao picking or other work when required. Employment is therefore continuous throughout the wet season, and no shortage of labour is experienced during the cacao reaping season.*

There is a slack period during March, April, and May which might, however, be avoided by planting grapefruit. The owner is managing director of a large sugar estate, to which labourers are drafted during this period, which coincides with the sugar crop season. By this combination of crops the labourers are assured of regular employment throughout the whole year, while the estate never experiences any serious shortage of labour. Rubber costs of production compare favourably with published figures for the East. This combination of crops ensures a high degree of financial stability, so that cultivation is not neglected owing to financial stringency. It represents one of the few attempts to arrange a diversification of crops with the deliberate attempt to secure uniformity of employment.

While rubber cannot be cultivated on all cacao estates, attention to this crop, or to others with similar seasonal demands for labour, would assist in solving the problem of providing regularity of employment throughout the year. It is known that the yields of individual cacao trees vary enormously even in the same environment (4). There is no high degree of correlation between the yields of the parent trees and their progeny (8), but experiments by the Department of Agriculture at River Estate, have demonstrated that certain trees are good parents, and can transmit their heavy bearing qualities to their budded and seedling offspring (6). It has further been shown that poor bearers can successfully be replaced by "supplies" known to have high bearing qualities (7).

It has been noted that most of the cacao estates were built up on the "contract system", and that very little care was exercised in selecting planting material. Even when discrimination was shown in selecting pods no relationship was necessarily shown between the yield of the parents and their progeny, with the result that every field contains a number of poor bearing trees which will not profitably respond to manurial or other treatment. Every estate also contains fields which, taking yearly variations into consideration, always produce high yields, and others which produce low yields. The new planting material will enable poor bearers to be replaced by heavy bearers, which will increase the demand for labour during the reaping season, when a shortage is already being experienced. This will accentuate the need for additional crops which will compensate for the fluctuations in labour demands on the cacao estates.

Further emphasis upon the need for diversification is being laid by the appearance of witchbroom disease, caused by *Marasmius perniciosus*, a fungus parasite (12), in several of the important cacao districts of the island. The trees require frequent inspection, and the removal of all "brooms," to ensure control, and, while this may be possible on high bearing and profitable areas, the cost may prove prohibitive on poor bearing and unprofitable areas. Neglected small holdings are likely to prove a reservoir of the disease from which it will spread to uninfected areas. It may prove desirable to eliminate areas which invariably produce poor yields, and to replant with some other crop, which will afford greater financial stability, and greater regularity of employment.

Summary.

The sugar and cacao industries suffer, in competition with other occupations, on account of the lower wages they can afford to pay, and the irregularity of the employment they offer.

By increasing the regularity of work the earnings of the labourer might considerably be increased.

I.—The Sugar Industry.

In attempting to relieve the shortage of labour during the crop season no additional assistance can be sought by transferring operations to other periods of the year. By hiring farmers to cart estate cane, the supply of labour can be augmented, while, by introducing mechanial cartage of cane, the demand for labour would be reduced. This period is always likely to remain a busy one.

Mechanical tillage has overcome the difficulties of the planting season, and, from November to January, great difficulty is experienced in providing the labourers with adequate employment.

II.—The Cacao Industry.

Mechanical labour saving devices have little scope in the cacao industry and reliance must be placed upon the diversification of crops.

* *See* Fig. 14.

With the Arabian and Robusta coffee the reaping seasons overlap that of cacao with which they compete for labour.

Although coconuts require a steady supply of labour throughout the year labourers could be drafted, without great inconvenience, to cacao reaping, but the areas where both crops can successfully be cultivated appear limited in extent.

Grapefruit, although profitable, has its greatest demand for labour at a period which partly overlaps that of cacao.

Rubber appears to be most nearly complementary in its seasonal labour requirements, and has the additional advantage that tapping can be stopped when the labourers are required for dealing with cacao.

Planting material is now available which will enable poor bearing cacao trees to be replaced by heavy bearers, and this, by increasing the demand for labour during the crop season, will emphasise the need for additional crops to reduce the seasonal fluctuations in employment. Some of the unprofitable areas might well be sacrificed for other crops.

The appearance of witch broom disease has introduced another incentive to diversification of crops since some cacao areas are likely to succumb.

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A PRELIMINARY LIST OF THE PENTATOMIDAE OF TRINIDAD, B.W.I.

By R. G. Fennah, B.A., F.R.E.S.

The order Hemiptera includes a vast assemblage of insects which often differ widely in appearance from one another, but possess in common a rostrum, or sucking beak, projecting backwards from the underside of the head when at rest. The great majority of these forms live on plants, piercing the tissues and sucking out the juices, and consequently the Order, with the exception of a few families, is very harmful to man on account of the damage it causes to crops.

Two Sub-orders are recognised: (*i*) the Homoptera, the members of which carry the wings folded roof-like over the body, includes Aphids, Cicadas, Scale Insects, Mealy bugs, White Flies, Froghoppers, Leaf Hoppers, and several other families; (*ii*) the Heteroptera, the members of which carry their wings folded flat, one directly overlying the other at the tip, includes in its twenty-six families both terrestrial and aquatic forms. Of this Suborder the Pentatomidae, comprising over 3,700 species, forms the largest family. Its members are usually easily recognised by (*i*) their shield-like shape, which has earned for them the title of "Shield Bugs", (*ii*) their large scutellum, a large plate, almost triangular in shape, extending from the prothorax to the base of the membrane of the wings when they are folded, (*iii*) the strong and unpleasant odour which they can emit when disturbed, a property which has been responsible for the term "Stink-bugs" so commonly applied to them.

The immature forms of Pentatomids are wingless and almost circular in outline when seen from above. They possess very feeble powers of migration from one plant to another, and like the adult, feed by sucking the sap from the host plant, which is often that on which the eggs were laid. Growth in size of the young takes place by a series of moults, usually five being passed through before the adult stage is reached.

In spite of the large size of the family, and, relatively speaking, of its individual members, there are very few Pentatomids which on present evidence can justly be held responsible for serious damage to crops. Of these one of the most notorious is present in Trinidad. It is the Green Stink Bug, *Nezara viridula*, which is widely distributed in many countries, including the United States, the West Indies, and South America. This insect is interesting in that, while its attacks on Citrus in Florida call for vigorous repressive measures, in Trinidad it appears to leave these trees untouched, and to confine its attention to

herbaceous plants such as Soy Beans and Tomatoes. Though quite common, it does not attain the standing of a major pest of agricultural crops in the island, and at present causes little loss.

Other Pentatomids which perhaps should be added to the list of insect pests in Trinidad are *Piezodorus guildingi*, a pale green bug with an orange-red band running across the posterior edge of the prothorax, commonly found on Soy Beans, and species of *Mecistorhinus* found on young shoots of Cacao. Both appear to be of negligible importance at the moment, but it is quite conceivable that under certain conditions their attacks might become sufficiently severe to cause unthriftiness of their plant hosts.

The remaining species in the list are of no importance agriculturally as they are too uncommon to have any appreciable effect on crops. It is interesting to note that the members of the Subfamily Asopinae chiefly feed on other insects, and so it is quite possible that the one member given below—*Alcaeorhynchus grandis*—is beneficial, though it is too uncommon to be of real value.

The small yellow-and-black Pentatomid *Mormidea ypsilon* is sometimes found in abundance on Ghamelot (*Setaria sulcata*) growing in plantations of Cacao, but it is very doubtful whether the insect has any useful effect in checking the weed, as the latter grows with a vigour which suggests that the environment is very favourable, and that consequently it can tolerate insect attack without being seriously affected.

The following list of Trinidad Pentatomidae has been prepared from material collected while the writer was staying at the Imperial College of Tropical Agriculture, Trinidad, during the period October, 1933 to June, 1934. Mr. W. E. China of the British Museum of Natural History kindly undertook the task of identifying the specimens, and his help in this connection is gratefully acknowledged. In addition, the writer wishes to thank Mr. A. M. Adamson, Mr. F. W. Urich, and Mr. D. Vesey-Fitzgerald for the assistance they afforded from time to time, and also the other members of the staff of the Entomological Department through whose appreciative interest several specimens were secured.

The Pentatomidae of local origin already in the collection of the Department of Entomology at the College were found to be represented in the writer's collection. As the time devoted to collecting was relatively short, it may confidently be expected that the list given below will rapidly be lengthened in the near future, and it is offered solely with the object of making a start in the listing of the Trinidad Pentatomidae, and also, it is to be hoped, in that of the whole Heteropterous fauna of the island.

There is little biological detail available as yet with regard to the insects named below. A few notes have been inserted where they have been thought useful.

Genera in parenthesis denote the original genus.

HEMIPTERA-HETEROPTERA.

Family PENTATOMIDAE.

Subfamily ASOPINAE.

Alcaeorhynchus (*Canthecona*) *grandis*, Dallas.
List of Hemiptera. 1851. p. 91.
A female was taken on *Cajanus indicus*, but was not observed to feed on this. Instars hatched from eggs laid by this specimen in captivity refused all of a large selection of fresh leaves and twigs. It is possible that the species will be found to be restricted with regard to food plants.
St. Augustine, 1933 (R.G.F.).

Subfamily CYRTOCORINAE.

Cyrtocoris (*Tetyra*) *gibbus*, Fabricius.
Syst. Rhyn. 1803. p. 141.
St. Augustine, 1933 (R.G.F.).

Subfamily PENTATOMINAE.

Acrosternum (*Pentatoma*) *nitida*, Westwood.
Hope Catalogue of Hemiptera. 1. 1837. p. 33.
The only regular food-plants so far noted in Trinidad are two species of *Ixora*, *I. coccinea* (red flowered) and *I. lutea* (yellow flowered).
St. Augustine, 1934 (R.J.O'C.).

Agroecus griseus, Dallas.
List of Hemiptera. 1851. p. 199.
St. Augustine, 1933 (D.V-F.).

Arvelius (*Cimex*) *albopunctatus*, de Geer.
Mém. 3. 1773. p. 331. pl. 34. fig. 6.
Taken on shrubs of waste land.
Aranjuez, 1934 (R.G.F.); St. Augustine, 1934 (T.H.K.).

Berecynthus (*Cimex*) *delirator*, Fabricius.
Mant. Ins. 2. 1878. p. 286.
One specimen was taken among low herbage in open forest.
Moruga, 1933 (R.G.F.).

Discocephala deplanata, Walker.
Catalogue of Heteroptera. 1867. 1. p. 185.
St. Augustine, 1933 (R.G.F.).

Edessa affinis, Dallas.
List of Hemiptera. 1851. p. 332.
Hibiscus spp. and Chandelier (*Leonotis nepetaefolia*), are common food plants of this species, which does not appear to be specialised in its feeding habits.
Spring Hill, 1933 (R.G.F.); St. Augustine, 1933 (R.J.O'C.).

Edessa (*Cimex*) *meditabunda*, Fabricius.
Ent. Syst. 1794. 4. p. 113.
Frequently found on Hibiscus and Soy Bean in all stages of development. Like the preceding species it is not a restricted feeder. The female lays about fourteen eggs at a time, often in two contiguous rows of seven eggs each. The eggs are pale green in colour, and each is one millimetre in height, and approximately spherical in shape.
San Fernando, 1921 (F.W.U.); St. Augustine, 1933 (R.G.F.).

Euschistus (*Pentatoma*) *atrox*, Westwood.
Hope Catalogue of Hemiptera. 1837. 1. p. 40.
This species varies in the extent to which the lateral angles are produced. Specimens have been taken on Soy Bean.
Diego Martin, 1921 (F.W.U.); San Juan, 1922 (F.W.U.);
St. Augustine, 1933 (R.G.F.).

Loxa affinis, Dallas.
List of Hemiptera. 1851. p. 198.
Mt. St. Benedict, 1933 (R.G.F.).

Loxa sp.
This species is much smaller than *affinis*, being about $\frac{1}{2}$-inch long.
St. Augustine, 1934 (R.G.F.).

Macropygium (*Cimex*) *reticulare*, Fabricius
Syst. Rhyn. 1803. p. 170.
Poole, 1922 (F.W.U.).

Mecistorhinus (*Cimex*) [Subgenus *Antiteuchus*] *mixtus*, Fabricius.
Mant. Ins. 1787. 2. p. 294.
This species was found only on *Terminalia catappa*. Instars were observed feeding on young twigs on several occasions. The females of this species exhibit some degree of parental care, remaining with the eggs until they are hatched, and frequently staying in company with the young until the second instar is reached. In spite of the constant presence of the parent the eggs may be heavily parasitised.
Mt. St. Benedict, 1933 (R.G.F.).

Mecistorhinus (*Dinidor*) [Subgenus *Antiteuchus*] *variolosus*, Westwood.
Hope Catalogue of Hemiptera. 1837. 1. p. 25.
St. Augustine, 1933 (R.G.F.).

Mecistorhinus [Subgenus *Antiteuchus*] sp.
St. Augustine, 1933 (R.G.F.).

Mecistorhinus (*Pentatoma*) *picea*, Palisot de Beauvois.
Ins. Rec. Afr. Amér. 1805. Hem. p. 148. pl. 10. fig. 3.
This species has been taken only on cacao as far as the writer is aware. The young twigs are the parts most readily attacked. The females watch over the eggs as do those of *M. mixtus*, but are unable to prevent their being parasitised in many cases.
St. Augustine, 1933 (R.G.F.).

Mecistorhinus (*Cimex*) *tripterus*, Fabricius.
Mant. Ins. 1787. 2. p. 294.
This is found in the same situations and has the same habits as the preceding species.
St. Augustine, 1933 (R.G.F.).

Mormidea (*Cimex*) *ypsilon*, Linnaeus.
Syst. Nat. 1758. (Ed. 10). p. 443.
Commonly taken on various members of the Gramineae. Of its wild hosts *Setaria* is one of the most heavily infested. Specimens have also been taken on Blacksage.
Balandra, 1933 (R.G.F.); Moruga, 1933 (R.G.F.); Spring Hill, 1934 (R.G.F.); St. Augustine, 1933 (R.G.F.); (Toco, 1934 (R.G.F.).

Nezara (*Cimex*) *viridula, var. smaragdula*, Fabricius.
Syst. Ent. 1775. p. 711.
The Green Stink Bug, the Southern Green Bug (of Florida); sometimes a serious pest of citrus in Florida; transmitter of a bacterial rot of tomatoes. In Trinidad does some damage to Soy Bean and tomatoes, but not on a large scale.
Common among cultivated herbaceous crops, especially those belonging to the Leguminosae and Solanaceae.
St. Augustine, 1933 (R.G.F.)

Ochlerus sp.
St. Augustine, 1933 (R.G.F.).

Piezodorus (*Rhaphigaster*) *guildingi*, Westwood.
Hope Catalogue of Hemiptera. 1. 1837. p. 31.
Leguminous herbs, such as Soy Bean, appear to be preferred hosts of this species. During the nine months of observation, breeding in the field continued uninterruptedly; the period required for an individual to develop from egg to adult is between twenty and thirty-two days.
St. Augustine, 1933 (R.G.F.).

Proxys (*Pentatoma*) *albopunctulatus*, Palisot de Beauvois.
Ins. Rec. Afr. Amér. 1805. Hem. p. 130. pl. 9. fig. 8.
Taken on Guatemala grass, Elephant grass, and rice
St. Augustine, 1933 (R.G.F.).

Thyanta (*Cimex*) *perditor*, Fabricius.
Ent. Syst. 1794. 4. p. 102.
Specimens were taken while feeding on Soy Bean and Sesbania.
St. Augustine, 1933 (R.G.F.).

Tibraca limbativentris, Stål.
Svensk Vet. Handl. 1860. 2. No. 7. p. 19.
St. Augustine, 1934 (R.G.F.).

Subfamily SCUTELLERINAE.

Sphyrocoris (*Pachycoris*) *obliquus*, Germar.
Zeitschr. Ent. 1839. 1. p. 94.
Taken on Soy Bean.
St. Augustine, 1933 (R.G.F.).

Symphylus (*Pachycoris*) *deplanatus*, Herrich-Schaeffer.
Wanz. Ins. 1837. 4. p. 3. fig. 344.
Taken on Blacksage.
St. Augustine, 1933 (R.G.F.).

Explanation of Collectors' Initials.

R.G.F.—R. G. Fennah, late holder of Colonial Agricultural Research Scholarship in Entomology.
D.V-F.—D. Vesey-Fitzgerald, Assistant Entomologist, Sugarcane Investigation Committee, Trinidad.
T.H.K.—T. H. Khan, Laboratory Assistant, Entomology Dept., I.C.T.A., Trinidad.
R.J.O'C.—Ruth J. O'Connor, Technical Assistant, Entomology Dept., I.C.T.A., Trinidad.
F.W.U.—F. W. Urich, Assistant Professor, Entomology Dept., I.C.T.A., Trinidad.

TOADS SAVE SUGAR CROP.

Biological control seldom extends to the importation of Amphibia, but great success has followed the establishment of the large toad *Bufo Marinus* in Puerto Rico. From two lots of this species brought to Puerto Rico from Barbados and Jamaica, millions of descendants have sprung, and the food of this host has consisted largely of the May-beetle (Science Service, Washington, D.C.). The sugar crop, which is the staple product of the island, was threatened by great numbers of the "white-grubs" of May-beetles, which swarmed everywhere in the soil, devouring the roots of the cane and of other plants as well, so that the planters were reduced to picking the grubs by hand. The introduction of the toad has reduced the May-beetles to scarcity, and the Puerto Rican Sugar Crop has been freed from its worst enemy.—(*Nature*, Vol. CXXXIV, Dec. 8, 1934, p. 877.)

WEST INDIAN NOTES.

(Compiled by the Advisory Department, Imperial College of Tropical Agriculture.)

Cotton.

The Sixth meeting of the Executive Committee of the West Indian Sea Island Cotton Association was held in Montserrat on 1st April, 1935. Mr. G. A. Jones, Commissioner of Agriculture, was Chairman. The following members were present—Mr. C. Griffin (Montserrat), Mr. A. Moir Reid (St. Kitts), Mr. E. Dew (Antigua). Barbados, St. Vincent and Nevis were represented by proxy.

The Committee passed resolutions granting full power of attorney to the Advisory Committee in England to act with regard to the registration of the trade mark and subsequent certification of goods thereunder, and authorizing the President and the Secretary to execute the necessary documents in connexion with the granting of the power of attorney. These documents were duly executed in Port-of-Spain on the 17th of May and forwarded to the Advisory Committee in England.

The Committee agreed to the proposal that Mr. T. A. Twyman be authorized to undertake on behalf of the Advisory Committee the work of issuing the trade mark and superintending its use. The Committee extended a vote of thanks to Mr. Twyman for the offer of his services.

Permission has been granted for extension of the area to be planted for the 1935-36 crop as follows—Antigua, up to 600 acres, St. Vincent, up to 2,000 acres, Barbados, up to 1,500 acres and Nevis up to 1,600 acres.

In a recent report on a visit to the Virgin Islands, Dr. S. C. Harland, Cotton Adviser, has recommended the planting in those Islands of the new Antilles cotton. The supply of seed is being withheld temporarily pending the report on the commercial samples of this cotton which have been sent to England from Carriacou in order that the most suitable strains may be selected.

Financial arrangements for putting into effect the proposed scheme for substituting the old strain of cotton in Carriacou with the new Antilles cotton have not yet been completed. It will therefore not be possible to put into operation the first stage of the substitution scheme before 1936.

The Fruit and Vegetable Industry.

The first meeting of the West Indian Fruit and Vegetable Council (Eastern Group) was held in St. Lucia on 11th and 12th April, 1935. The work of the meeting was summarised in the editorial columns of the last issue of this journal. The report of the Council meeting is being printed and will shortly be available for circulation.

Bananas.—The industry continues to grow and a record shipment of a little over 7,000 bunches was made by the C.N.S. *Lady Nelson* at the end of April. The export figures for the first four months of 1935 are set forth in the following table.

(Stems)	Bananas.			1935	
	Jan.	Feb.	Mar.	Apr.	Total.
Trinidad ..	5,606	3,673	4,071	2,875	16,225
Grenada ..	1,159	571	2,233	1,512	5,475
St. Lucia ..	916	559	1,367	2,036	4,878
Dominica ..	3,005	1,750	3,019	3,489	11,263
Total ..	10,686	6,553	10,690	9,912	37,841

Vegetables.—Exports of tomatoes for the first four months of 1935 are shown in the following table. It will be seen that exports from Islands other than Montserrat have been almost negligible, but exports from Montserrat have increased in comparison with the previous year.

(Boxes)	Tomatoes*			1935	
	Jan.	Feb.	Mar.	Apr.	Total.
Montserrat ..	213	942	4,633	8,263	14,051

Exports of miscellaneous vegetables for the first four months of 1935 are given in the following table :—

Miscellaneous Vegetables (to end April, 1935)	Carrots (crates)	Sweet Potatoes (crates)	Onions (crates)	Eschallots (crates).	Pumpkins (lb.)	Mixed fruit and Vegetables
Montserrat ..	780	250	377	82	—	—
St. Lucia ..	—	—	—	—	7,831	318 pks.
Nevis ..	—	—	—	—	—	17 brls.

During his recent visit to the Virgin Islands, the Assistant Commissioner of Agriculture was granted an interview with Dr. Robert W. Claiborne, President of the Virgin Islands Fruit Products Company in St. Thomas. The latter explained that he had succeeded in creating a definite demand in the United States of America for jams and preserves made from tropical fruits, and that the prospects of establishing an industry along these lines were very favourable. Delicious jams, chutneys and conserves were being made from mango, papaw, guava, cashew, cocoplum, marmee, seagrape and other tropical fruits. The preserves

* St. Vincent 264 ; Nevis 24 ; St. Lucia 2.

are bottled in small, neat glass bottles, and marketed, in groups of six, in very attractive native-made baskets. The establishment of a similar factory in the British Virgin Islands for manufacturing preserves for export to Canada is under consideration.

A Visit to the Virgin Islands.

The Assistant Commissioner of Agriculture and the Cotton Adviser to the Commissioner of Agriculture visited the Virgin Islands early in April.

These picturesque and attractive Islands depend entirely on the products of agriculture and livestock farming. The Islands are extensively cultivated by peasant farmers, but progress and prosperity are greatly retarded by the absence of suitable markets for their produce. For many years they found a ready and very remunerative market for their produce in the neighbouring American Islands, but conditions have changed and these marketing opportunities are no longer so favourable. The Islands lie off the steamship routes and consequently the export of produce to more distant markets involves problems of transport which cannot easily be overcome.

Judging by export and import figures for the year 1934, the worst phase of the economic depression would appear to have been passed. The value of exports increased by 25 per cent. from £8,000 to £10,000, and of imports by approximately 33 per cent. from £3,200 to £4,300. The chief exports in 1934 were livestock £6,000, charcoal £1,200 and fresh fish £1,100; and the chief imports were flour £1,700 and cotton goods £800.

The urgent need for the Presidency is a cash crop for cultivation. The conclusion has been arrived at that cotton is the most suitable crop for this purpose, and it now remains for a decision to be made as to whether better results are likely to be obtained from the new strain of Marie Galante cotton, named "Antilles" cotton, or from Sea Island cotton now that the market for this class of cotton has shown definite signs of improvement.

Some effort has been made by Government to improve the livestock industry by the recent introduction of a $\frac{7}{8}$ bred Zebu bull. It is considered that weight is the most important factor for the cattle industry, and accordingly the recommendation has been made that a high grade Sussex bull be introduced. It is recognised also that the standard of pigs would be raised by the introduction of the Large Black or Berkshire breeds.

The chief function of the agricultural operations of the people is the production of food crops. Unfortunately the cultivation of the chief food crop, sweet potato, is being seriously threatened by the West Indian sweet potato weevil (*Euscepes batatae*) commonly known as "Scarabee". Methods for the control of this pest have been recommended. But it is considered advisable that other food crops should be looked for, and with this end in view it has been recommended that attention should be paid to the increased cultivation of yams, eddoes, corn, cassava, black-eye peas, bonavist and other types of beans, and breadfruit trees. Arrangements have already been made for the introduction of certain varieties of some of these crops, in addition to new early maturing Barbados sweet potato seedlings.

Cotton Pests.

THE PINK BOLLWORM OF COTTON (*Platyedra gossypiella* Saund.) IN MONTSERRAT.

Hosts of the Pink Bollworm during the Close Season for Cotton. I. The Seaside Mahoe or John Bull Tree (*Thespesia populnea*).—This plant has been known for many years to be a host of pink bollworm in Puerto Rico, St. Croix and elsewhere. Following upon certain recommendations, the Montserrat Agricultural Department has been conducting regular examinations of *Thespesia* pods from various localities, with the result that pink bollworm was found in numbers at Little Bay and Trants during March. In each place the insects were found as larvae in all stages of development, indicative of the suitability of *Thespesia* as an alternative food plant of this pest. Fully-fed larvae were found in infested pods which had fallen from the trees at Little Bay.

The local Government, has now arranged for the destruction of *Thespesia* wherever it occurs in Montserrat. Fortunately the number of these trees is very limited, and their eradication should present no difficulties, at least under Montserrat conditions; in Antigua, however, where pink bollworm is also a serious pest of cotton, the eradication of *Thespesia* might prove impracticable owing to the expense involved in comparison with the value of the local cotton industry. Nevertheless, whilst there exist Close Season laws for cotton and okra it is of course imperative that *Thespesia* be included in the schedule.

II. Wild Cotton (*Gossypium*).—Two infestations of pink bollworm in wild ("rogue") cotton in the northern section of Montserrat were reported to the Agricultural Department whilst the entomologist was in the island. One of these was at Brinn's Ghaut, and was inspected. The plants, at least two years old, were thriving, and formed the sub-dominant in association with Loblolly (*Pisonia subcordata*), Kidney Guava (*Tecoma stans*) (dominant) and Dogwood (*Piscidia erythrina*) in typical xerophytic country on a relatively protected hillside at 300 feet altitude and a quarter of a mile from the windward coast. They were about ten feet in height and had flowered and bolled freely. The seed was extremely viable as shown by the numbers of young seedlings in the vicinity. Among 30 bolls examined at the Botanic station, one was punctured and two others contained medium-sized larvae in the active feeding stage. The other infestation was at Rendezvous Bay on the leeward coast, and in a similar type of wild cotton. Judging by the small sample of bolls examined the infestation by pink bollworm was rather more severe here than at Brinn's Ghaut. Needless to

say, steps were immediately taken by the Department for the destruction of the plants and a thorough clean-up of the localities where they had been found. The stringent enforcement of the Cotton Protection Ordinance is necessary to abolish these natural breeding places of the pink bollworm in the cotton-growing islands.

Other Cotton Pests in Montserrat.

Cotton Stainers (*Dysdercus andreae* L.) were literally swarming on *Thespesia* at Little Bay in March. Other food plants noted were *Sida rhombifolia* and *S. carpinifolia* ("Twelve O'Clock Bush"), both of which are common and widespread weeds throughout the lowlands, especially along roadsides and in proximity to cultivated lands. Mole Crickets (species undetermined) are stated to injure germinating seedlings locally. A hibernating(?) larva of the Cotton Bollworm (*Heliothis obsoleta* Fabr.) was found on the soil underneath a small boulder in a field of newly-planted cotton at Elberton.

Cotton Pests in Antigua.

There was a serious outbreak of cotton pests at Brooke's estate, near Morris Bay, in February. This area contained about 20 acres of six months old Sea Island cotton in a good state of growth, but owing to heavy rains in November the expected yield of 20 bales fell to only eight. The second crop was a total loss owing to the combined attack of insect pests.

Practically every branch of every plant was covered with a thick incrustation of the Black Scale (*Saissetia nigra* Nietn.) and the foliage was badly infested with the Cotton Aphis (*A. gossypii* Glov.); both of these pests, however, were heavily attacked by local natural enemies.

Cotton Stainers (*D. andreae*) were present in numbers, and in swarms on some of the plants; the damaged bolls amounted to fully 100 per cent. A count was made by the Cotton Inspector to determine the infestation by pink bollworm, which was found to be 66 per cent. In December the infestation of this same area was 16 per cent. These facts are interesting in that they demonstrate the increase of the pest at a time of the year which has been assumed (elsewhere in the British West Indies) to coincide with the resting stage.

Citrus Pests in Dominica and St. Lucia.

Serious damage to the root-stocks of Lime by "root-borers" has been reported from various localities in these islands. It appears that the larvae (grubs) of several species of weevils (*Exophthalmus, Diaprepes,* and possibly others) and Hardback Beetles *Cyclocephala* spp. are involved. Unfortunately, by the time the damage becomes apparent through the dying-back of the trees it is too late to effect economic control measures, though it may be mentioned that "Vaporite" has been employed with some measure of success locally in Dominica. There is no doubt that these pests constitute a serious problem in the islands affected and are deserving of thorough investigation.

Brevities.

Mr. William O'Brian Donovan has been appointed Agricultural Superintendent (on probation) of Grenada with effect from 1st January, 1935.

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Mr. S. H. Evelyn, Cotton Research Officer, St. Vincent, paid a visit to the Imperial College and Cotton Research Station, Trinidad, from 28th March to 4th April.

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Mr. C. C. Skeete, Assistant Commissioner of Agriculture, visited the Virgin Islands, Antigua, St. Lucia and Dominica during the period from 27th March to 27th April.

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The Government of Trinidad kindly loaned the services of Captain H. V. Metivier, O.B.E., for a visit to St. Lucia from 5th to 8th June to advise on local veterinary matters.

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Dr. A. E. S. McIntosh, Geneticist to the British West Indies Central Cane Breeding Station, visited Antigua from 2nd to 9th April to study the sugar cane varietal requirements of that Island.

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Mr. G. A. Jones, Commissioner of Agriculture, visited Antigua, Montserrat, St. Kitts and St. Lucia during the period from 27th March to 13th April, and St. Vincent from 7th to 16th May.

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Mr. E. H. Brown of Messrs. Dawson, Shores, Punch & Co., London, and a member of the Advisory Committee in England of the West Indian Sea Island Cotton Association visited Trinidad during May.

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Dr. S. C. Harland, Cotton Adviser to the Commissioner of Agriculture, visited the British Virgin Islands early in April for the purpose of reporting on the possibility of re-establishing a cotton industry in the Islands.

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Mr. J. G. Davies, Sugar Technologist to the Imperial College of Tropical Agriculture, visited St. Vincent from 7th to 16th May for the purpose of investigating and making recommendations for the improvement of the local syrup industry.

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Mr. H. E. Box, Entomologist attached to the Agricultural Advisory Department, visited Montserrat from 7th to 12th May in connexion with the introduction of the citrus mealy bug parasite *Cryptolaemus* referred to in the last quarterly notes.

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The first number of the West Indies Fruit and Vegetable Bulletin was issued in May, 1935. This Bulletin, which is for official use only, has as its main object the presentation as early as possible of investigational work and of progress reports in connexion with crop data, field experiments, low temperature work, technical aspects of marketing and marketing data undertaken by Government Departments of Agriculture.

A COMPARATIVE TRIAL BETWEEN B.H. 10/12 AND P.O.J. 2878 SUGAR-CANES

By R. Cecil Wood, M.A., I.C.T.A.

The Barbados seedling cane B.H. 10/12 is the most popular cane in Trinidad at present, and is probably the most widely grown. Among other introductions that have recently been made, P.O.J. 2878 has attracted notice from the vigour with which it 'springs' and the very heavy 'plant' crop which it produces: its reputation as a ratooner is not so good.

One fault which has been quickly realised about this P.O.J. cane is its indeterminate habit of growth, which makes the crop at any time a mixture of ripe and unripe canes, and consequently of poor quality. Observations made it seem likely that part at any rate of this trouble might be avoided by altering the time of planting, and this point was borne in mind in laying out the experiment, and the two varieties were compared at three different times of planting.

The land on which the experiment was conducted is a deteriorated alluvial yellow loam, originally acidic in reaction and of low fertility. The field received a dressing of 7.8 tons of ground limestone in June, 1931 and 20 tons of pen manure was applied after a preliminary green manure crop in 1932. The canes were planted in October and December, 1932 and in February, 1933. The dry season in 1933 was particularly severe and a dressing of 1 cwt. of Sulphate of Ammonia was given in June to stimulate growth. The plant crop was harvested in March, 1934. The first ratoon received a full application of 3 cwts. Sulphate of Ammonia and 1 cwt. each of Superphosphate and Muriate of Potash immediately after cutting, and was reaped in March, 1935.

It is of interest to see what results have been obtained from these two crops.

Firstly, as far as the time of planting is concerned, the experiment has been a complete failure for the season was against the later-planted plots, which accordingly have given a significantly lower yield.

The comparison between the two varieties is more interesting. The figures show no significant difference in favour of either, as far as tonnage of cane is concerned. The actual figures are given below:—

Variety.	Tons per acre.	
	Plant Cane, April, 1934.	First Ratoon, March, 1935.
B.H. 10/12 ..	30.9	23.6
P.O.J. 2878 ..	34.0	27.9

In neither case is the superiority of P.O.J. 2878 sufficient to make it reasonably certain that the result is not due to chance.

As far as quality goes, all that can be said is that an analysis made on a random sample while the canes were ripening does not show any very marked difference.

Date.		Brix.	Purity.	Pol. % Cane.
Feb. 19	B.H. 10/12 ..	15.95	78.31	11.88
	P.O.J. 2878	16.00	76.44	11.13

There is thus, on these figures, little to choose between the canes, and there is little chance that, if this is generally the case, the new-comer will oust the established variety.

SUGAR NOTE.

Compiled by the College Department of Sugar Technology.

P.O.J. 2878 and its Inconveniences in the Factory. —*F. Poey.*

P.O.J. 2878 is at present the most popular variety throughout all sugar-cane countries; after six years of experience it is now the variety most extensively grown in Cuba, replacing with advantage the old Cristalina; it is especially adapted to high, dry, red soils of the Matanzas clay type.

There is some complaint however, about this magnificent cane on account of its poor defecation, especially when compared with Cristalina. The juice of P.O.J. 2878 forms a great deal of foam, which makes it difficult to recognize the point at which the boiling should be interrupted, with the result that this point may either be passed or not reached. In either case the settling process is prolonged and decantation is rendered difficult. Given time enough to settle, P.O.J. 2878 gives a large amount of sugar, but the time required raises the question whether it might not be more economical to look for another variety free from this defect. There is also some complaint of the quality of the bagasse as fuel.

As regards a remedy for the defect of poor decantation, it is suggested that good results might be obtained by varying the alkalinity at distinct periods of the decantation (fractional liming?) or by sulphitation followed by a moderate carbonation. Addition of phosphoric acid will improve the defecation, but in some cases this may not be economical. At the present time it seems that a practicable solution will be to restrict the area given to P.O.J. 2878 and grind it along with other varieties, which will be more advantageous than to abandon the variety altogether.—(*Facts about Sugar*, Vol. XXX, No. 5, p. 180, 1935.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Rubber Powder.

The rubber industry in Malaya is showing interest in the successful experiments in rubber powder for manufacturing purposes. It is stated that high hopes are entertained for a new, simple and cheap process in which it is believed many important manufacturers are extremely interested. The claim is made that the first process on the plantation produced a fine granular form of rubber almost comparable to whitewood sawdust in appearance, and that this result is produced on an extremely simple machine; within a few moments of the arrival at the estate factory the liquid latex can be converted into this stable form. The Rubber Powder Company has tested a plant in Amsterdam on a fairly large scale, and this has been used for experiments with ammoniated liquid latex shipped from the East. The whole plant was recently shipped to Ceylon and erected on a rubber estate there, so that, for the first time, latex direct from the tapper's buckets was used to feed the plant. The tests proved that powders of all grades, from coarse granular to fine dust, could be produced.

It is understood that the Ceylon experiment has proved so successful that the machine will be offered to Malayan estates, and a keen demand is anticipated. It is visualised that this will involve an important transformation of rubber methods. Not only can 50 lb. of powdered rubber be packed for transport purposes into a space which holds only 45 lb. of sheet or 35 lb. of crêpe, but the home manufacturer is likely to find that the powder additionally advantageous, in that it will ensure a standard product with the full serum content, and will therefore be superior to sheet or crêpe in tensile strength. One well-known planting expert in Malaya has declared that rubber powder promises ultimately to supersede sheet and crêpe. The adoption of the process in Malaya will inevitably be slow; but certainly the whole of the rubber industry is watching the development with very great interest.—(*The Planters' Chronicle*, Vol. XXX. No. 5, 1935, p. 109.)

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Citric Acid Fermentation on Solid Materials.

Citric acid may be produced by fermentation with *Aspergillus niger* for 38 to 60 hours on solid materials containing sucrose or molasses. The citric acid yield is 45 per cent. of the sugar content of the molasses, and 55 per cent. of the sucrose, if pure sucrose is used. The sugar solution is absorbed in beet pulp or cane pulp, which furnishes a large surface for the fungus, growing in the spore-forming state. Sterilization of the mass to be fermented is not necessary, because the citric acid, which is formed after one day, suppresses the growth of contaminating organisms. —(*Ind. & Engin. Chem.*, Vol. XXVII, Feb., 1935, p. 201.)

The Chilean Nitrate Industry.

The reorganization of the Chilean nitrate industry would appear to have had very sucessful results, judging from the fact that the export figures rose from 230,800 tons in the first eight months of 1932 to 897,500 tons in the corresponding period of last year. The Chilean nitrate combine "Cosach", was liquidated by Government action at the end of 1932, and subsequently a sales company, the Nitrate and Iodine Sales Corporation, was formed. To this company all nitrate producers were required to deliver their product at a price covering costs exclusive of capital charges; 25 per cent. of the profits was allocated to Government in lieu of taxes, and the remainder to the producers. The two associate companies of Cosach—the Anglo-Chilean Nitrate Company and Lautaro Nitrate Company — were separated from Cosach. The somewhat complicated proceedings terminated in June, 1934, with the formation of the Nitrate Company of Tarapaca and Antofagasta, incorporating the remaining 34 associates of Cosach. The Chilean nitrate industry now consists of eight units, including the concern just mentioned, the Lautaro and the Anglo-Chilean companies, and five others of much smaller size, each having its allotted quota of production.—(*Industrial Chemist*, Feb. 1935. pp. 50-51).

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Chemistry of Fats.

Prof. T. P. Hilditch (*Chemistry and Industry*, 54, 139, 163, 184; 1935), in his Jubilee Memorial Lecture to the Society of Chemical Industry, directed attention to recent investigations of the chemical composition of fats. It had been assumed that the normal constituents of fats and oils were tristearin, tripalmitin and triolein, other substances being regarded as abnormal. It is now known that some of the supposed fatty acids are mixtures of two other acids in equimolecular proportions, margaric acid, for example, consisting of palmitic and stearic acids. Again, the assumption that simple triglycerides (containing three identical fatty acid radicals) are predominant is incorrect; in the natural fats the triglycerides are usually mixed. The major component acids of a fat often exceeds three and may be as many as ten or twelve in number, and their relative proportions vary widely in different cases. In the case of fruit-coat fats, the major component acids are practically only palmitic, oleic and linoleic acids, but in many other seed fats other quite specific acids are found. Cruciferous seed-fats, for example, contain large quantities of the unsaturated erucic acid, Umbelliferae contain petroselinic acid (an isomer of oleic acid), &c. What Prof. Hilditch calls an 'even distribution' rule appears to operate in regulating the composition of the glycerides. A number of general questions, such as the conversion of carbohydrates into fat in living organisms, and the catalytic hydrogenation of fats, were also considered.—(*Nature*, Vol. CXXXV, No. 3414, p. 552, 1935.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.).

	Foreign.	*Preferential.*
	s. d.	*s. d.*
25th April	5 1½	8 10½
2nd May	5 0	8 9¾
9th May	5 0¾	8 9¾
16th May	5 0¾	8 9¾
23rd May	4 11¼	8 8¼
30th May	4 10½	8 7½
6th June	4 10½	8 7½
13th June	4 9¾	8 6¾
(14*th June*, 1934)	4 7½	8 9

The market, after a period of moderate activity has taken a disappointing turn with raw values dipping to 4*s.* 10½*d.* It is difficult to find any justification for the fall in sugar values except perhaps for the fact that there is uncertainty in regard to Cuba's future policy. Unless a renewal of the International Agreement can be organised, Cuba will be free of any Chadbourne restrictions after the 31st August and the world is at present awaiting some authoritative statement as to what Cuba's policy is likely to be after that.

* * *

COFFEE.—The market has presented few fresh features of interest. There has been a good home trade demand for the best qualities of all growths, especially Costa Rica country cleaned, but export orders have been very scarce. The general position of this article has again slightly deteriorated as in the absence of any recovery in Brazilian markets the pressure to sell from all quarters is unabated.

* * *

BANANAS.—There has been a slight improvement in the demand, and the price of Jamaicas to wholesalers has been increased by 10*s.* per ton to £17 5*s.* delivered London and £17 nearest station. Brazilians continue in fair demand at the unchanged rate of £17 per ton delivered nearest station. The imports into the United Kingdom for the fortnight ended 4th May amounted to 774,054 bunches consigned by the following countries: Jamaica, 631,639; Canary Islands 4,646; Guatemala, 60,406; Brazil 77,363. —(*West India Committee Circular*, 23rd May.)

* * *

GRAPEFRUIT.—Is in fairly good demand in spite of the cold weather. To-day's prices (all for 'Marsh' seedless) are:—South African 13*s.* to 14*s.*; Californian, 12*s.* to 17*s.*; Trinidad, 13*s.* to 16*s.* The imports into the United Kingdom for the fortnight ended 4th May amounted to 30,523 cwt. consigned by the following countries: Trinidad 4,036; Jamaica, 546; Palestine, 16,758; U.S.A., 6,224; Brazil, 2,368; and other countries, 591.—(*West India Committee Circular*, 23rd May.)

COCOA.—On account of unsettled business conditions brought about by political developments in Europe and United States of America the market has been quiet although on the whole fairly steady. Offerings from primary points are scarce at prices higher than those ruling in terminals markets. Accra is being quoted at 22*s.* 3*d.* and locally $5.30 a fanega is being paid for plantation cocoa.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	pence per lb.
24th April	5 3-4
1st May	5 5-8
8th May	5 5-8
15th May	5 7-8
22nd May	6 1-16
29th May	6 1-16
5th June	5 15-16
12th June	6 1-16
(13*th June*, 1934)	6 9-16

The market has been steady to firm with prices creeping upwards. Sentiment has been helped by the shrinkage in the Singapore and Penang Stocks, the settlement of the Chevrolet works strike and heavier buying by the U.S.A. manufacturers. The total American consumption of the article in the first four months of the current year at 177,624 tons is reported to have exceeded the previous record level of 1929 by about 800 tons.

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COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian F.G.F. Sakel.*
26th April	6.78	8.45
3rd May	6.81	8.38
10th May	6.88	8.42
17th May	6.90	8.43
25th May	7.01	8.35
31st May	6.93	—
7th June	6.77	—
14th June	6.76	—
(15*th June*, 1934)	6.61	8.35

Prices for American have shown little change with a moderate demand for the article. Retail sales of West Indian Sea Island have been reported at 14*d.*, 14½*d.*, 15½*d.* and 16*d.*

* * *

LIME PRODUCTS.—*Lime Oil.*—Handpressed is scarce and in demand at 35*s.* per lb. *ex* wharf London. Distilled is firmly held for 22*s.* 6*d.*, but the weather has been against the demand. *Lime Juice.* —Buyers of Concentrated give no encouragement and shipments cannot be recommended. Raw is slow of sale at 2*s.* to 2*s.* 6*d.* according to quality. —(*West India Committee Circular*, 23rd May.)